MACHINERY.

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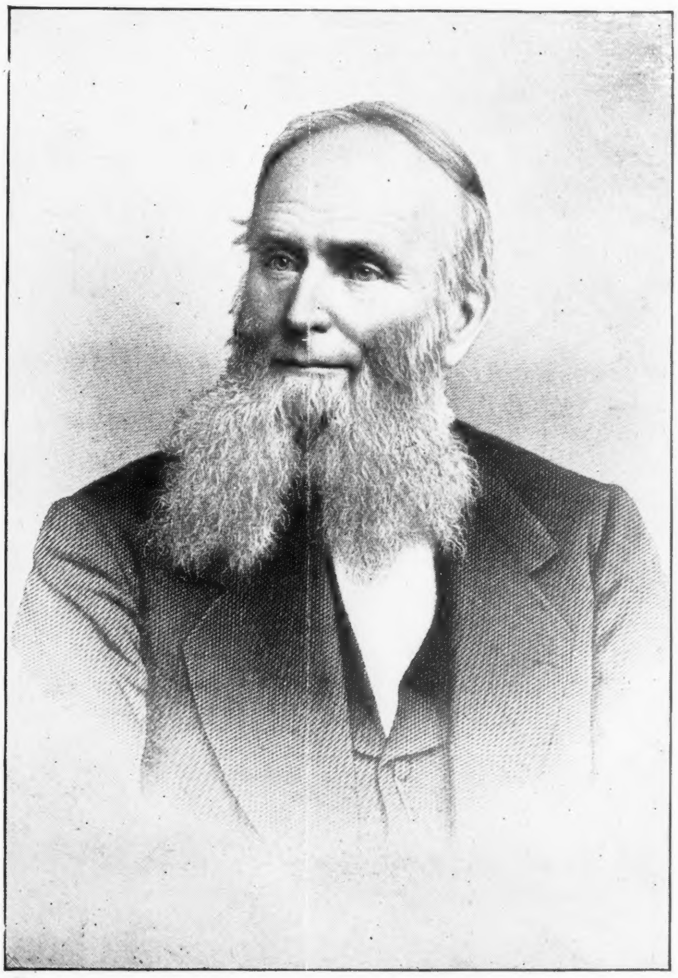
THE CRAMP SHIP-YARDS.

FRED H. COLVIN.

SIXTY-EIGHT years ago William Cramp, then a lad of sixteen, commenced his ship-building career as an apprentice for Samuel Grice, at his yard in Kensington, now a portion of Philadelphia, and not far from the present location of the famous Cramp ship yards. During his apprenticeship he doubtless looked forward to the time when he would have a yard of his own, for he had not been a journeyman long—in fact, he was barely twenty-three—when he bought with his savings a small lot on the Delaware River, in Kensington, which was to form the nucleus for the present immense plant. This was in 1830, and the new ideas and methods which William Cramp introduced into his work speedily secured for him the position of a leader in the business of ship-building.

The opening of the Civil War inaugurated a new departure in ship-building, that the firm—which has now become William Cramp & Sons—was quick to take advantage of. The day of the wooden ship was past, the iron hull was now a necessity, steel being practically still in the future.

William Cramp's experiments and experience proved invaluable to the Government, and the last years of the Rebellion a large amount of naval work was done at his yard. In March, 1862, the keel of the famous iron-clad steam frigate, the *New Ironsides* was laid, and seven months later she was ready for service, a feat of ship-building which made her constructors celebrated. The progress which had been made by the Cramps as designers thirty years ago is shown by the fact that our protected cruisers are still modelled after this old vessel. Five other vessels, among which were the monitors *Yazoo* and *Tunxis*, and the steam frigate *Chattanooga*, of 3,500 tons, were also constructed at their yards during the closing years of the war.



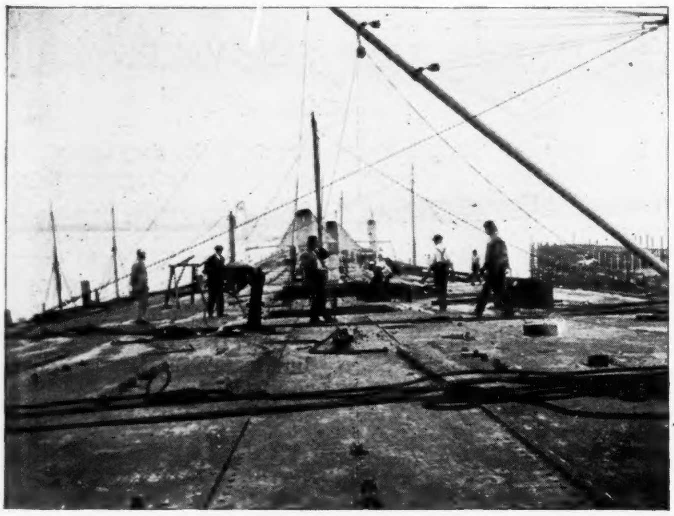
Wm. Cramp

The Cramp yards may be called the birth-place of the new navy. The *Terror*, *Yorktown*, *Vesuvius*, *Baltimore*, *Philadelphia*, *Newark*, *Columbia*, *New York* and *Minneapolis*, all familiar to our readers, were constructed here. There are now in the yard in process of construction, four cruisers, two new steamers for the American line and some smaller vessels, including a collier for the Reading Railroad.

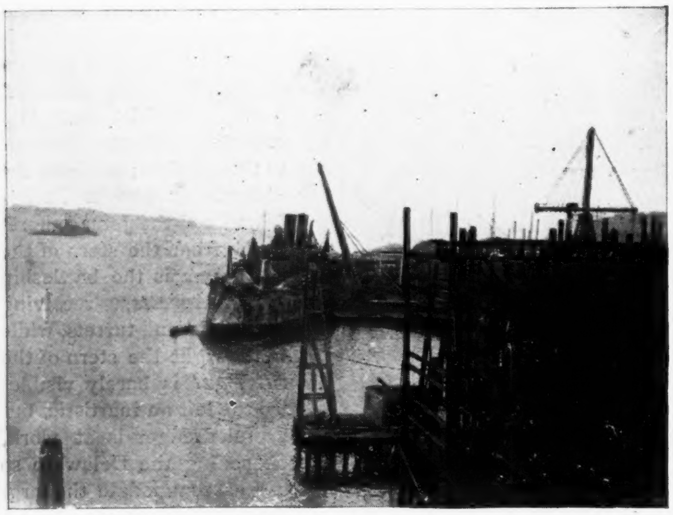
All the buildings except the office are unpretentious and erected more for use than show. The main building, which is over 1,000 feet long, contains the mould loft and machine shop No. 1, tools for shearing, bending and punching plates. Next to this are the boiler shops, machine and erecting shops, power plant for compressing air, generating electric current for motors, lights, etc. Beyond these are the joiner shop for the production of all woodwork on the vessels, plate-forming shop, mast shop, foundry, forges, etc. The main entrance is through the punching and shearing shops, from which arise the clangor of hundreds of busy workmen, and just beyond, partially obscured by the forests of timber, rises the hull of the *St. Paul*, one of the new American liners. To the left is her sister ship, the *St. Louis*, while half hidden between them and dwarfed by comparison, both as to size and occupation, we find a collier for the Reading line. Long gangways lead to the upper deck of the *St. Louis*, some fifty feet in the air, and which presents an expanse of iron flooring that seems endless. A view in the direction of the stern is given showing over 500 feet of deck, including workmen, hoisting-derricks and the canvas funnels supplying air to those below; while in the distance is shown Petty's Island and the Jersey shore. South from the stern of the *St. Louis* is the battleship *Massachusetts*, receiving her armor and turrets, while to the right the stern of the *St. Paul* is barely visible. To the left an inartistic, but useful dredger is at work, deepening the Delaware so as to accommodate the largest vessels. Down in the immense hull of the *St. Louis*, on the fourth deck, counting from the top or main deck, the recently imported electrically driven deck-planer, which closely resembles a lawn-mower, is at work, but the light was insufficient for a good photograph. Beside the *St. Louis*, near the gangplanks, are the steel fighting masts for the *Indiana* and *Massachusetts*, which have two fighting platforms, the upper 70 feet above the water line and carrying a Gatling gun; the other, 10 feet below, armed by four rapid fire one pounders. Back toward the stern of the *St. Louis* is the huge shaft coupling shown on the hand car, 5 feet 10 inches long, with a 22-inch bore and keys 2½ inches by 5 inches each, while ten 4-inch bolts will clamp the shaft firmly in position. Still further back men are at work on the *St. Louis*, drilling and riveting, fastening the huge steel castings which hold the outer bearings of the twin-screws firmly in position. Everything is on a gigantic scale. The outer diameter of these bearings for the *St Louis* is 40 inches, while the hole which is to receive the *lignum vitæ* bushing is 27 inches in the rough. Less than half of this casting is shown in the view, for the distance from center

to center of the bearings is 24 feet, the screws being 19 feet in diameter and having five feet clearance. Three-bladed screws will be used having manganese bronze blades bolted against a zinc lining to a steel hub.

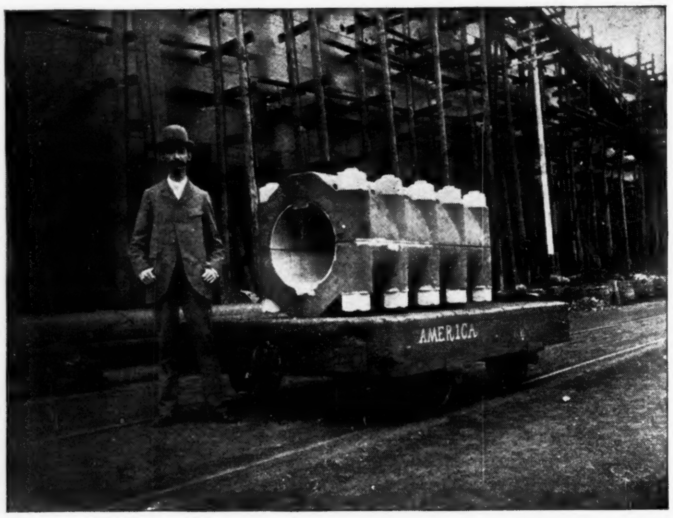
The mast shed is near the power house, where steel masts 90 feet long are in course of construction. Here several portable power drills driven by electric motors through Stow flexible shafting are in use, while others are operated by direct steam in a Moffet drill. In an open space accessible from all points are the hydraulic shears for cutting almost anything handled in their work. The plate bending shed, whose heavy cast iron floors, five inches thick, with stake holes at regular intervals attracts attention. Here the heavy sheets are bent and formed in various and often intricate shapes, long experience making the work less difficult than it seems, a large bending or "kinking" press assisting in the operations. The *Indiana*, sister to the *Massachusetts*, lies not far from here receiving her turrets and armor, which can hardly be called the finishing touches however, as she will



MAIN DECK OF "ST. LOUIS."



BATTLESHIP "MASSACHUSETTS."

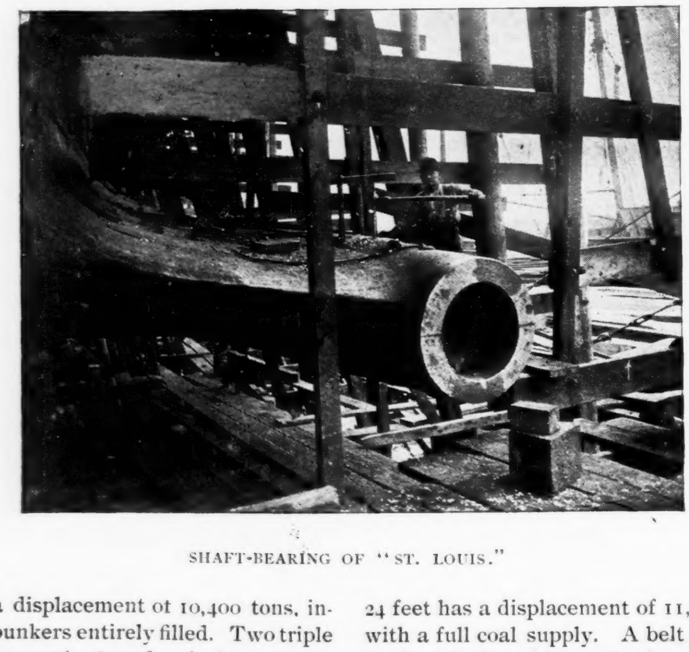


SHAFT COUPLING.

not be completed for a year at least. This is due solely to the decision of the Naval Department in August, 1893, to use Harveyized armor on all the vessels under construction. All the unfinished portions are supplied by the Government, so the responsibility for delay can be clearly placed. The side armor and batteries are lacking, and while the guns are ready, the mounts are still unfinished. The small turrets are being placed on both the battleships and an army of workmen are hastening their completion as much as possible. These cruisers have a length of 380 feet, breadth 69 feet 9 inches, while from the under side of the main deck to the inner bottom is 38 feet. With the normal draft of 24 feet they will have a displacement of 10,400 tons, increasing to 11,000 tons with coal bunkers entirely filled. Two triple expansion engines, with cylinders 34½, 48 and 75 inches respectively, with a common stroke of 42 inches, provide the propelling power, and together are calculated to develop 9,000 H. P. at 129 revolutions, with steam at 160 pounds pressure. Running at 134 to 136 revolutions, nearly, if not quite, 10,000 H. P. will be obtained. Four boilers, having four 40 inch furnaces in each end, making 32 furnaces in each vessel, will furnish the steam required. These boilers are 15 feet 9 inches in diameter, 19 feet 4 inches long, have steel shells $1\frac{13}{32}$ inches thick and a ratio of heating to grate surface of 35 to 1.

On the way to the *Massachusetts* are the plate sheds, with their huge bending rolls and other plate handling tools, the main building, 1,164 feet long, with an average width of 72 feet, making over 83,800 square feet covered by one roof, on one side, and on the other all the vessels in process of construction on the ways.

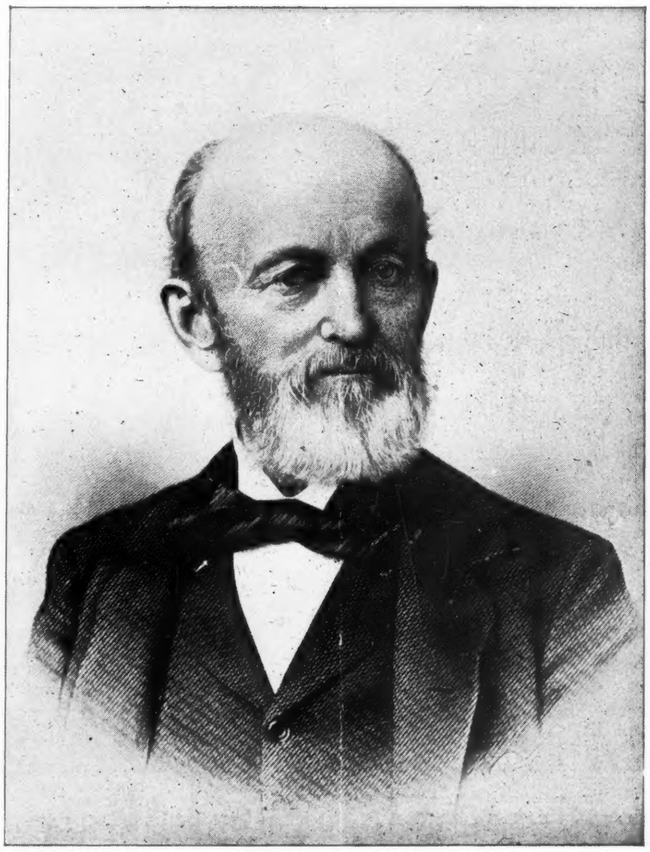
The huge floating crane, aptly named *Atlas*, lies in the dock, and an excellent view is obtained from the capstan of the *Massachusetts*, giving one of the shops for a background. This crane is the largest machine of its kind in the world, its iron hull, steel arms and braces which rise 116 feet in air, and its capacity of 125 tons make it capable of easily and quickly handling the heaviest boilers ever constructed. The four boilers of the *Indiana* were deposited in place in four hours and twenty minutes, and one of these weighing 72 tons, was lifted, carried 80 feet and deposited in the hold in 26 minutes. In the extreme right of this view the hull of the *Iowa* is seen, which will be a sea-going battle ship and is the last of the naval vessels now under contract, while between the *Iowa* and the *St. Paul* the form of the armored cruiser *Brooklyn* is rapidly assuming definite shape. Her load water line length is 360 feet, extreme width 72 feet 2½ inches, moulded depth 39 feet 4⅝ inches, and at normal draft of 24 feet has a displacement of 11,300 tons, increasing to 12,200 tons with a full coal supply. A belt at the water line of Harveyized steel, 14 inches thick and 7 feet 4 inches wide, with a wood backing, extends 186 feet amidships, forming her heaviest armor.



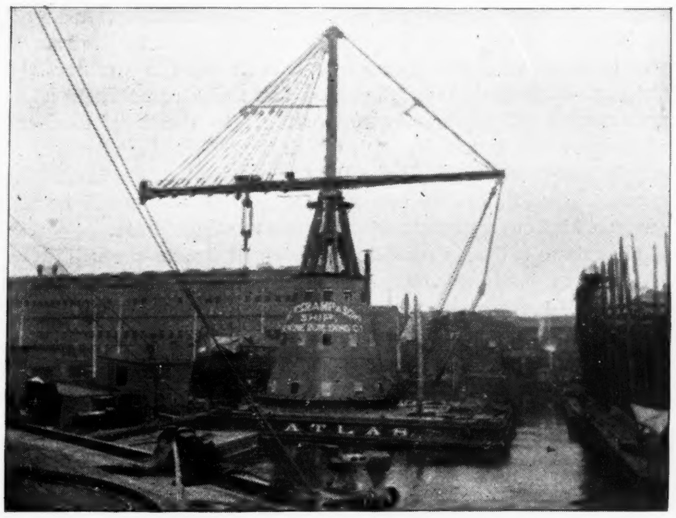
SHAFT-BEARING OF "ST. LOUIS."

Four 12 inch, eight 8 inch, six 4 inch breech loading rifles and twenty-two rapid fire and machine guns complete the armament. Manned by 512 men, including officers, with a coal capacity of 10,000 miles at economical cruising speed, she will make a valuable addition to the new navy.

The armament of the *Indiana* and *Massachusetts* is said to be the most diversified of any ever placed on vessels of this size, and consists of four 13 inch breech loading rifled guns, forty feet long and weighing sixty-three tons each, to be mounted in pairs in the two main turrets. Four small turrets containing pairs of 8 inch guns, four 6 inch guns mounted broadsides amidships in the upper casemate, and a secondary battery of twenty 6 pounders complete the list, being capable of discharging 6,680 pounds of metal at one complete discharge, while the armor, not including the protective deck weighs 2,695 tons. From the iron deck of *Atlas*, a good view of the boilers being completed in the yard is obtained, only a portion of the row being shown, the comparatively small figures of the men indicating the dimensions of the boilers. At the further end of the row of boilers the sound of heavy hammers on steel invites a closer inspection, which reveals groups of men seated on large plates of heavy armor, diligently plying sledges between lines drawn diagonally from corner to corner, almost a foot apart, and the natural inquiry arises, what are they trying to do? A closer examination discloses an excellent example of what every machinist knows as "peneing;" the surface of these plates, which are about 6 by 8 feet and 6 inches thick, are being stretched by hammering until they assume the desired shape. Seeing that these huge pieces of metal can thus be changed in form by comparatively light blows, one is apt to speculate on the possibilities connected with the extended application of this principle.



Chas H. Cramp



FLOATING CRANE "ATLAS."

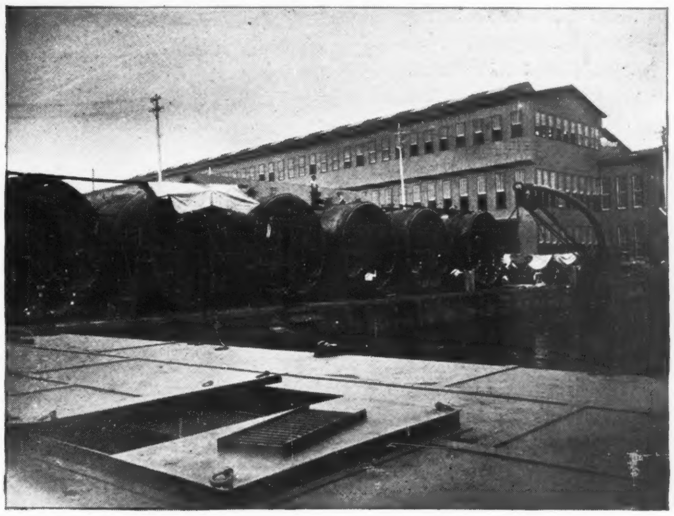
The erecting department of the engine shops is crowded with work in all stages of completion; four large triple-expansion engines for the American liners being the most prominent features, and it is to be regretted that the light did not admit of a satisfactory photograph being made. A similar condition was revealed in the boiler shops, and here, too, the light proved unsatisfactory.

In every ship-yard, great and small, a launch is an event to be looked forward to as the culmination of a long and trying period of effort, mental and physical, with a spice of excitement attending the result. In Cramps' yards the process is not materially different from the primitive methods with which we are all familiar, except as to the magnitude of every accessory. When ready for launching, two broad "ways" are built against the bottom of the vessel, the keel blocks being knocked away when these are completed. Thousands of pounds of the best tallow is placed between the two planks forming the "ways," and when all is ready the planks, whose front ends are joined, are sawed apart and the vessel slides into the water—carrying the upper planks—which glide over the tallow and leave it smoking hot.

These heavy iron-clads require an inclination of ⅝ inch to the foot to secure a sucessful launch, while the ocean steamers, being longer for the same weight, have only ½ inch.

Below the yard is the dry dock, the largest in the country when built, and its 462 feet of length, mean width of 70 feet, and depth of 22 feet on the sills, still entitle it to respectful consideration. The view here shows the stern of a light house tender having rudders repaired, and close inspection will show broken places on the propeller blades. The dock at present will hold 54,000,000 gallons of water, which can be emptied out in a little over 45 minutes by the centrifugal pumps employed, whose capacity is 120,000 gallons per minute. This dry dock is to be extended 200 feet and made to conform to modern plans as soon as the new Port Wardens' line is established and permission obtained from the Secretary of War. Two piers will also be extended to 600 feet, while another 1,300 feet long will be built, which can accommodate the *Campania* and *Lucania* end to end. The works now cover 31.3 acres, including the brass foundry and gun shops, and extend along the Delaware river for 1,303 feet. About 5,600 men are employed at present.

In 1872 the firm became an incorporated body under the style of the William Cramp and Sons Ship and Engine Building Company, and since the death of the founder in 1879 his oldest



LARGE MARINE BOILERS.

son, Mr. Charles H. Cramp, has been President and General Manager, and still holds that position, assisted by an able staff, including Mr. Henry W. Cramp, Secretary and Treasurer, Mr. Edwin S. Cramp, Superintending Engineer, having as his assistant the former Chief Engineer of the Navy, Nathan P. Towne, while Mr. Lewis Nixon is Superintendent of Construction. Immediately under these officers are forty heads of departments in the yard.

LIGHTHOUSE TENDER IN DRY DOCK.

* * *

NO BLUE PRINTS.

A word may be said about the drawing-office system at the works of Messrs. Galloways', Ltd. It is the practice to make but one drawing, and from this no tracings are taken; the drawing is carefully finished and dimensions marked on, it has then a coat of white hard spirit varnish put on it, and is mounted on a board and sent in to the works. It might be thought a somewhat risky proceeding to have but one record of a design, but it has been found in practice that a drawing has never been lost or destroyed, except on one occasion. Messrs. Galloway do not believe in the now popular system of blue prints, and they are sure that if there is but a single drawing care will be taken to finish it accurately, and that it will not go astray. Messrs. Galloway state that the paper which is found to take the varnish best without sizing, is that made by Messrs. T. & G. Hollingworth, whose mills are in Kent. If alterations are required, the varnish may be removed by a little methylated spirit, and the corrections can then be put on in red ink. There are over 8,500 drawing now in stock, the system of registration being very complete.—*Engineering, London.*

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CHIMNEY DRAFT.

W. Barnet Le Van.

It is generally supposed that the draft of chimneys is due solely, or almost so, to the expanding of the enclosed heated air in the chimney, thereby giving it a buoyant or ascensional power, which is known as draft. But unfortunately for this theory we find a decided draft in chimneys without heat or fire passing through them.

The fact is as to drafts, like electricity, we know very little as to their cause and effect, independent of the fact that all the technical journals are profuse in formulæ to show the amount of work produced by electricity and draft respectively. Should one ask an engineer versed in electricity or draft from the mechanical standpoint, what produces the phenomena, if he is candid he will frankly admit he does not know.

A gentleman of high standing in electrical engineering when I asked him to define electricity replied that he did not know, but it was produced in one way by revolving at a high velocity a coil of wire in space, and combing, as it were, the electricity from the surrounding atmosphere. Rather a romantic answer, but one which, in a way, defines the operation.

As to draft in chimneys although applied in the Arts for over 1800 years yet no one can say with certainty how it is produced.

If any one will look over the transactions of the Mechanical Engineering Societies and read the discussions on chimney draft they will be surprised at the differences of opinion expressed by the learned men who have discussed the subject. But there is one fact as to which there can be no doubt, namely, to produce a good draft in any chimney the height of the chimney is an essential factor for the economic combustion of fuel.

The draft power of chimneys is dependent on their area of cross-section and height, other things being equal. The ordinary tables and formulæ for dimensions of chimneys for various horse-powers of boilers is based on the following assumed or asserted data.

First. The draft power varies as the square-root of the height.

Second. The power varies directly as the area of the shaft.

Boiler makers as a rule assume the above to be correct. Now as to the facts in practice: The draft-power based on the above, and the tables deduced therefrom, a chimney 48 inches in diameter and 150 feet high, would be only sufficient for 425 horse-power boilers, whereas the writer has actually produced 1000 horse-power (based on 30 pounds of water evaporation) by a chimney of the above dimensions, and proposes to add a 200 horse-power boiler as soon as may be required.

I cite the above to show the fallacy of all the formulæ as to draft-power of chimneys. It is assumed according to the above rule that their height should be eight times the area of the chimney, the quality or kind of fuel is not stated.

The important factor, grate surface, depends on the different kinds of fuel used, and the conditions under which the fuel is burned; again, the tables are also based on a temperature in the chimney of 600 degrees A very high temperature, it would seem, having in view proper economy. The intensity, or degree of heat evolved by the fuel varies in proportion to the rate at which it burns; the greater the draft is, the greater the amount of work will be produced from the same fuel. The power of draft is directly proportional to the height of the chimney, and the velocity with which the external air flows in to supply the draft depends upon the temperature of the ascending gases. The higher the temperature is the lighter will be the gases, which consequently will create a stronger draft.

That there is draft in a chimney without fire no one will deny. In a great many chimneys the infiltration of air through the masonry has, no doubt, a great influence to retard the velocity of the heated gases, when in use. The intensity of draft is independent of the area, and depends upon the difference between the inside and outside temperature, the degrees of heat produced by the fuel varies in proportion to the rate at which it burns; the greater the draft is, the greater amount of work that will be produced from the same fuel. This goes to show the importance of tall chimneys, therefore the power of draft is directly proportional to the height of the chimney, and the velocity with which the external air flows in to supply the draft depends upon the temperature of the ascending gases.

Air at 520 degrees temperature expands to double its volume at 32 degrees, therefore, the higher the temperature is the lighter will be the gases, which, consequently, will create a stronger draft.

A rapid draft is, in one respect, equivalent to a large fire-grate area, since it enables more fuel to be burned in a given time, and thus increases the power of the boiler in generating steam. A rapid draft, however, has this advantage, that, inasmuch as the temperature of the furnace is higher when the same quantity of heat is generated in a small space than it will be when generated in a large space, the heat is transmitted much more rapidly to the water in the boiler in the case of the strong draft, by reason of the higher temperature thus obtained. The manufacturing requirements of modern times demands the building of high chimneys, so as to enable more fuel to be burned in a given

space and time, and thus increase the power of the boiler.

The present fad of having a very short or low chimney in connection with a fan or blower for exciting the fire is, in my opinion, a mistake, and as to its first cost there is no saving over a high, well-proportioned chimney. The former system, too, has the disadvantage of involving continual expense to keep it in good running order independent of its deterioration of the boilers. Again, the former plan causes the delivery of the heated gases in the lower stratum of air whereby it is wafted into the surrounding dwellings along with the smoke and fine particles of carbon which, of course, is very objectionable.

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THROTTLING VS. AUTOMATIC ENGINES.

W. H. Wakeman.

Every engine in use at the present time, and all those which have outlived their usefulness and been consigned to the scrap heap, may be classed under one or the other of the above types, and as statements are frequently made concerning them which demonstrate that those who make them are not always well informed on the subject, a discussion of some of the principles involved will be of interest.

Let us review some of the statements referred to, that we may fully understand the matter.

We are told, *First*, that every throttling engine uses steam expansively to a greater or less degree. *Second*, that all of the so-called automatic engines use steam non-expansively at times, as when the load calls for a longer point of cut-off than is provided for automatically. *Third*, that throttling engines use the same amount of steam at each stroke regardless of the load. *Fourth* that whatever efficiency may be found in the automatic engine is due to the fact that a certain needed amount of steam is admitted at each stroke, when the supply is cut off and here the matter ends. *Fifth*, that with the automatic engine, if the exhaust should take place at the same instant that the cut-off does, and if all of the steam should be immediately expelled from the cylinder, it would be an improvement over present practice. *Sixth*, that in some places the throttling engine has proved to be more efficient than the automatic. *Seventh*, that the first cost, and extra expense for repairs of the automatic engine, is so great as to make it an unprofitable investment. *Eighth*, that the automatic engine is suitable for large factories, where it will be well cared for, but that for every day hard service the throttling is superior. *Ninth*, that in none of the automatic engines in use at the present day, does the valves close rapidly enough to secure best attainable results, and if inventors would turn their attention to this defect they would be well repaid for time given to it.

None of the above statements are wholly true, but some of them contain enough truth to be misleading, while others are neither more nor less than mistaken ideas. It is true that if the steam in our boilers was not expansive or elastic we should not be able to use it at all, for it would be the same as water, which is non-compressible, and to all intent and purposes is non-expansive. To this extent all engines utilize the expansion of steam, but this is a matter outside of the questions which we are considering, although it is mentioned in order to cover the ground.

Regarding the first statement made, there are many throttling engines still in use that take steam from center to center, and consequently do not use steam expansively in the smallest degree, for as the valve in such a machine has no lap, the steam is never interrupted in its flow from the boiler, or at the most it is but checked and not entirely cut off, for while there is a point in the travel of the valve when it is momentarily closed, still the action of the valve gear is such as to render this of so little account as to make it proper to ignore it. In other words, as soon as one steam port is closed the other one is opened. Many of our slide valve throttling engines cut off the steam at about three-quarter stroke, and so use steam expansively, but the governor has so reduced the pressure that at the point of cut-off it has lost much of its value, and furthermore the position of the crank is such that what little expansion does take place is not very effective, for to produce the best results the exhaust port must be opened just before the stroke is completed.

Concerning the second statement, in many of the automatic engines the limit of cut-off is said to be at one-half stroke, but this is really true of but few of them. If the steam valves of an ordinary Corliss engine are set so that when the wrist-plate is in the middle of its travel they do not lap the ports, they are the same as a D slide-valve which has no outside lap, and in this case if the load calls for more than half stroke cut-off, the steam must follow full stroke. But the valves should not be set in that way, but should lap over the edges of the ports when the wrist-plate stands centrally on its stud, consequently if the cut-off does not take place before the piston has traveled one half of its stroke, it will still be cut off at about seven-eighths stroke, which is as early as some of the throttling engines ever cut off. Again, some of our automatic engines do not reach the limit of cut-off until the piston has traveled seven-eighths of its stroke, beyond which no steam can be admitted, so that steam is used expansively at every stroke made. A few engines are made in which the cut-off valve closes automatically up to half stroke, after which no steam can be admitted, thus giving a ratio of expansion of 2 at the latest possible cut-off. If an automatic engine taking steam at nearly boiler pressure cannot maintain its speed with a cut-off at half stroke, it is time to order a larger engine or to increase the boiler pressure.

There are apparently many steam users who believe in the doctrine set forth in our third statement, probably because the point of cut-off can not be varied, as the valve has a fixed travel. For illustration suppose we have a throttling engine taking steam at full stroke. The writer had charge of such an engine for several years. Now the fact in the case is that this throttling engine measures out, or, more properly speaking, weighs out just the quantity of steam needed at each stroke to carry the load put upon the engine at that time. For proof of this, if our engine is so loaded as to require an average pressure (not a mean effective pressure) above a vacuum of 30 pounds, it will take a certain weight of steam at each stroke according to the size of the cylinder. Now let the load be increased until the average pressure above vacuum is 60 pounds, and what is the result? The weight of steam used is almost exactly double what it was when the average pressure above a vacuum was 30 pounds. Any reader who wishes, can prove this by referring to a table of the properties of saturated steam, and noting the weights stated for the pressures mentioned. This is proof conclusive that even in the throttling engines running with fixed cut-off, the steam is dealt out for each stroke in quantities to suit the requirements of the load at that particular time. No automatic engine could by any possibility do this more accurately or carefully. This is but a reasonable conclusion, for unless the quantity of steam was suited to the load, how could the speed be maintained under changes of load?

Passing on to a consideration of our fourth statement, we are perfectly willing to admit that in the automatic engine the amount of steam needed to do the work is measured out accurately for each stroke, although it requires a more complicated calculation to prove than in the case of the throttling engine; but that is the *end* of the matter, we are not willing to admit, for the efficiency of the automatic engine in the use of steam is due directly to the expansion of the steam after the cut-off has taken place, and it can be attributed to nothing else. We know that the automatic engine is more efficient than the throttling engine, for we know of numerous instances where it has been shown, and our own practice has demonstrated it beyond all doubt.

The fifth statement has been made by men who are not wholly ignorant of the subject that they write about, but who have made a mistake here that we will endeavor to correct. It is true that all back pressure, except that necessary to give proper cushion, is detrimental and should be reduced to the lowest possible point, but it is not good practice to exhaust the steam at a high pressure, because its energy has not all been utilized. We are told that when we have taken into account the volume of the steam admitted to our cylinder up to the point of cut-off and the pressure existing at that time, we have determined the amount of energy that it contains. As we write there is an article before us from which we quote: "A given volume of steam at 60 pounds or any other given pressure, holds within its compressed grasp a given measure of energy that is capable of performing a given amount of work, and by no mechanical device, or method of utilizing it, can one iota be added to the energy already possessed and by nature's laws given it. The idea that using steam expansively adds anything to its energy and power-producing qualifications must be abandoned, and a basis more in conformity with natural laws established." The above is a mixture of truth and error, in which the latter predominates. We do not dispute the fact that a given amount of steam at a stated pressure contains a certain amount of energy and that no mechanical device can add to this energy, but we maintain that in the case of a throttling

engine taking steam from center to center, the whole of the energy in the steam is not utilized, but much of it is allowed to go to waste. In the case of an automatic cut-off engine, if the steam should be exhausted as soon as the cut-off has taken place, a vast amount of energy would be wasted in the same manner. Mechanical devices have been invented and are extensively used, whereby the power-producing qualifications of the steam are greatly enlarged or added to. In short, the automatic engine does not add anything to the natural energy of the steam in question, but it is a mechanical device whereby nearly all of the natural energy may be utilized. This is a distinction with a difference. Suppose that instead of using steam to propel the piston, we use a coil spring capable of expanding to four feet more than its length when compressed. We have an engine with a stroke of four feet which we put on its inside center, take off the cylinder head and place the spring against the piston! We next turn the fly-wheel until the piston has traveled one foot. Will any one claim that all of the energy in the spring is exhausted now? We think not, and yet that is exactly what some writers claim concerning steam in the automatic engine.

Here the question naturally arises as to the amount gained by the expansion of the steam. A well-known writer and recognized authority on steam and the steam engine, expresses it as follows:

"Cutting off at one quarter and getting four-fold expansion, the work done during the last three quarters stroke, while expansion is taking place, is measured by the hyperbolic logarithm of 4, the expansion rate, this hyperbolic logarithm of 4 being 1.3863. In other words, if the engine gave out 400 horse power with full steam, it should, with cut-off at one-quarter, give out 100 horse power during the one-quarter period of full steam, and 138.63 horse power during expansion; total, 238.6 horse power, with one-quarter the steam required to give out 400 horse power."

We consider the above to be very clear and correct. He goes on to say, "Cutting off at one-quarter and expanding four fold, the average proportionate pressure above vacuum during expansion is best obtained by dividing the hyperbolic logarithm of the expansion rate, by the ratio between full steam and the expansion part of the stroke. Thus the expansion part of the stroke in this case is three times the full steam portion, and the average pressure during expansion should be $1.386 \div 3 = .462$ times the initial pressure."

If the foregoing is a mistake we should like to see it demonstrated by an engine built to exhaust the steam as soon as it is cut off, both automatically, and its efficiency proved.

As to the sixth statement we would say that it is quite possible that instances might be found where properly designed and well made throttling engines have proved more efficient than poorly designed and carelessly made automatics, but such comparisons are justly odious because they are not fair.

The seventh statement has proved to be a great comfort to the manufacturers of throttling engines, and we will suppose will continue to be kept in remembrance by them, and also by their disciples, but the question is, "Is this true or not?" We are inclined to think that if the matter were thoroughly ventilated it would be found that a Corliss, or some other good form of automatic engine, can be bought at a very slight advance over the cost of a thoroughly well made throttling engine, and we know that the cost of repairs is so small with a well-cared-for automatic, that we do not understand how it could be less with any other type. Several years ago the writer had charge of a throttling engine that took steam from center to center, as before stated, and consequently was very wasteful of fuel. By persistent effort in their behalf, the owners were induced to put in new valves, to be used in connection with an automatic cut-off device, or expansion gear. It required two weeks time to make the change and cost several hundred dollars, but the saving in fuel amounted to 35 per cent., and in one year this paid the entire cost of making the change, and during the three and one-half years that we were in charge after the alterations had been made, the automatic gear did not require the expenditure of one dollar for repairs. This may be an exceptional case, but we are satisfied that it can be duplicated many times over. Could a throttling engine by any possibility have shown a better record?

We propose to meet the eighth statement by the presentation of facts in a case well known to the writer, and which cannot be disputed. About seven years ago a certain firm put in a new Corliss engine, made by a well-known builder. These people believe that an engineer is about on a par with a good laborer, and pay him accordingly. The consequence is that they get just the kind of service that they pay for, but the engine has been at work nearly every day since it was put into service, and during all of this time not five dollars have been spent in making repairs. We are not advocating this rating or paying of the engineer, for we know it to be false economy, but could a throttling engine do any better?

If inventors follow out the idea presented in the ninth statement, they will make a mistake and have their labor for their pains. If any one will study up the wrist-plate motion on a Corliss engine in connection with good vacuum dash pots, they will see that the valves are moved very rapidly, and that here as well as in some other kinds of automatic engines, the steam pressure is maintained up to the point of cut-off, which is very sharply defined, leaving absolutely nothing to be desired in this direction. The point is considered a small one by some engineers, but if it has any advantage we may secure it by selecting the proper machines already in the market, as it is not necessary for us to wait for one to be invented.

We do not claim that all of the automatic engines are desirable, for some of them are monstrosities; but this is due to the fact that the method of working the steam which is employed in them has proved a remarkable success, making the demand for them very great, so that consequently some of them are badly designed and are not well built machines, making it necessary to use good judgment in selecting an engine for a given duty. Many engine builders manufacture both types, but the larger sizes are nearly always of the automatic kind.

* * *

ANALYSIS OF DIFFERENTIAL GEARING.

W. L. Cheney.

The descriptions of even the simpler forms of differential gearing, as given in most text books, are in such scientific language that the student, unless with a natural talent for mathematics, often becomes discouraged, and if he has later to deal with the subject practically, either goes by some text-book "rule," or gets some friend to make the calculations for him, neither of which practices tends to make a man rely upon his own strength, which it is not necessary to state is a good thing to do, either in mechanical or any other walks of life. As differential gearing will often accomplish in machine design what hardly anything else will accomplish in some cases, and as the rectifying of mistakes in designing these gears is often particularly expensive, it is thought that a clear explanation of the principle upon which they work, in simple language and plain figures, might have some value to some of the readers of Machinery.

The simplest form of differential gearing is where one gear is fixed, another gear of the same or nearly the same *diameter*, but with either more or less teeth, is placed by the side of the fixed gear, and a third gear, usually a small pinion with any number of teeth that will run with *both* of the other gears, revolving *around* them and engaging with *both* of them at once. See Fig. 1. Assuming the fixed gear to be at the *back*, as shown by the dotted lines, and the moving gear at the front, and the moving gear to have *fewer* teeth than the fixed gear, then the motion of the front gear will be the *reverse* of the direction of the motion of the pinion, for reasons which can be more clearly seen by a study of the figure than by following a description. And conversely, the motion of the front gear will be the *same* as the direction of motion of the pinion when the front gear has more teeth than the stationary gear at the back.

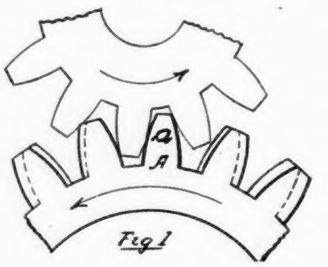

Fig 1

Assuming that the teeth A *a* of the front and back gears are together when the pinion is at the position shown; then the pinion having made one revolution around the two gears, *some other* tooth of the moving gear will evidently occupy the position formerly occupied by the tooth A, the tooth "a" of the stationary gear of course not having moved (as it is impossible for it to move, the gear being *fixed*). If the *moving* gear has *one* tooth more or less than the fixed gear, it will be the *first* tooth away from the tooth A which now occupies the place formerly occupied by A; if two teeth, more or less, it will be the *second* tooth from A, and so on.

That is, the *number of teeth* in the *moving* gear is the *denom-*

inator of the fraction representing the *amount* of motion of the gear to one revolution of the pinion around it, and the *difference* between the number of teeth in the moving and fixed gears respectively, is the *numerator* of the fraction, and this *difference* must be *plus* or *minus*, according to the *direction* of motion wanted: in other words, the *number* of teeth of the fixed gear has nothing to do with calculating the amount of motion wanted, and this is where the confusion usually comes in making such calculations: that is, it is only necessary to decide how much motion is wanted, design the *moving* gear to give the denominator of the fraction and the fixed gear with enough teeth; either more or less, according to *direction* wanted, to give the numerator.

For those who are not satisfied unless they can see some *letters*, the matter may be generalized as follows:

Let number of teeth in moving gear = m
" " " " " fixed " = n

then *amount* of motion $= \dfrac{m-n}{m}$ or $\dfrac{n-m}{m}$

A little more complicated form of differential gearing is shown in Fig 2: The pulley is loose on shaft, and carries with it the pinions C and D, these pinions both being tight on the small shaft E running through a hub of the pulley; the gear A is fixed, and the gear B is tight on the shaft that the driving pulley revolves loosely on. Assuming the numbers of teeth and other things to be as described and shown, then, first: One revolution of the pulley causes pinion C to make $\frac{15}{18}$ revolutions in the same direction as the pulley, and as the pinion D is tight on the same small shaft as pinion C, the pinion D *must therefore* also make $\frac{15}{18}$ revolutions, and as the pinion D contains 17 teeth it must move $\frac{15}{18}$ of 17 teeth, which is $14\frac{1}{6}$ teeth.

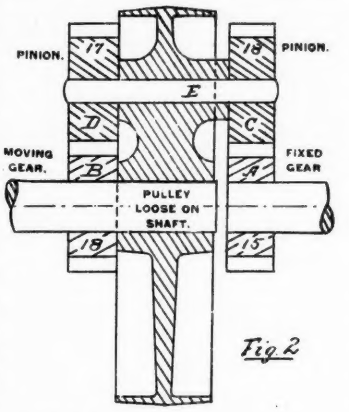

Fig 2

Second: *Assume* for an instant that the gear B is fixed; the pinion D would *then* move $\frac{16}{17}$ revolutions to one of the pulley. That is, the pinion D *would* move 16 teeth to one revolution of the pulley; but as the gear B is *not* stationary (but on a shaft free to revolve), and the pinion D *actually* moves but $14\frac{1}{6}$ teeth; therefore the pinion D *must* carry the gear B *along with it* (that is, in the same direction) an amount equal to the difference between 16 teeth (which the pinion D would need to travel if B was fixed) and $14\frac{1}{6}$ teeth, which the pinion D actually travels. This difference is $1\frac{5}{6}$ teeth, or, reducing to a fraction, $\frac{11}{6}$ teeth, and as *one* tooth of motion is equal to $\frac{1}{16}$ of a revolution of gear B, the amount of motion of B would evidently be $\frac{1}{16}$ of $\frac{11}{6}$, which is $\frac{11}{96}$ revolutions of gear B to one revolution of the pulley.

Looking from another standpoint, the whole train of gearing may be considered as drivers and driven respectively, and the conditions may be stated as follows:

$$\frac{\text{Drivers, } 15 \times 17}{\text{Driven, } 18 \times 16} = \frac{85}{96}$$

That is, the motion of gear B is $\frac{96}{96} - \frac{85}{96}$, which is equal to $\frac{11}{96}$ *less than* A, but as A is fixed, the motion of B must be considered as *minus* $\frac{11}{96}$, or, in other words, it is $\frac{11}{96}$ revolutions in an *opposite* direction to which the gear A was *assumed* to be running, and as this *opposite* direction is the *same* direction in which the pinions C and D and the small shaft E are *actually* running, it follows that under the conditions the gear B moves $\frac{11}{96}$ revolutions in the *same* direction as C, D and E, and consequently in the same direction as the pulley.

When the conditions are reversed, so that the *ratio* in the train is *more than* 1 (instead of less than 1, as above), the gear B would evidently move in the *opposite* direction to the pulley.

* * *

COMPOUND CYLINDER RATIOS.

"Argus."

In a paper on the compound engine, recently read before the Brooklyn Engineers' Club by Mr. David Anderson, he remarked: "It must be run to at least three-quarter of its capacity to make any showing. And when from poor design or a large receiver the expansion in the receiver is excessive, it follows that there must be a great waste in this expansion as it is doing no work, merely 'filling a box,' as I once heard it expressed. * * * * There is also a tendency to cut down the relative proportions of the two cylinders, which is a move in the right direction. Cylinder areas of 4 to 1 relatively, were common enough a few years ago, now 3 to 1, and even 2 to 1 (the latter on locomotives) are considered the correct thing. Four to one is too large a proportion for good work, even for marine engines, where the load is constant and is much too large for the fluctuating load of an ordinary mill."

I take pleasure in differing from Mr. Anderson in nearly every particular, the first portion being the least objectionable. While it is undoubtedly true that a compound, and any engine for that matter, should not be run under-loaded, I know of one instance where this is done without disastrous results to the coal pile. The engine was designed for 150 pounds of steam, but the load being very light they are at present carrying but 85 pounds, and the steam consumption is but a trifle over 16 pounds per horse-power per hour. And further, when we consider that this engine has all the features which Mr. Anderson condemns, large ratios (6 to 1 in this case) and has a very large receiver, much larger than the low pressure cylinder in fact, we must see that the statements he has made are not always borne out by current practice. Regarding the receiver, it is evident that after it is once filled the expansion therein will depend on the amount of steam drawn out by the low pressure cylinder, for if this does not reduce the receiver pressure, there can be no expansion therein, and a gage will indicate a practically constant receiver pressure in most cases. And as in many, if not most cases of modern practice, the low pressure cylinder has a cut-off which is adjusted by the engineer independent of the governor, we find that such variations of load as occur in mill service are not detrimental, as might be supposed. The increased volume of steam in the high pressure increases the receiver pressure, giving the low a higher initial with which to take its share of the load, and when the regular extra load comes on, as at night, when dynamos are thrown on, the engineer simply adjusts his low pressure cut-off to maintain the required receiver pressure. The conclusions concerning the ratios of cylinders seems to be a step backward, for with few exceptions the former ratios are at least maintained, and in many cases increased. Very few compound locomotives in this country have a less ratio than $2\frac{1}{4}$ to 1, and some even more. In stationary work we see a tendency among some builders, and those who obtain the best results, to increase areas and steam pressures in compound engines rather than build triple expansion, and when we can cite several successive plants of comparatively small powers which have given results that astonished old expert engineers, it must be conceded that a small ratio is not a *necessity* under all conditions. In none of these instances is the ratio less than $5\frac{1}{4}$ to 1 and ranges to $7\frac{1}{8}$ to 1, while the steam consumption is in some instances less than 12.5 pounds per horse-power per hour as attested by reliable parties. If large ratios and large receivers are all wrong, why do we find this succession of remarkable results in steam consumption, lower than any similar *series of results* from any smaller ratios? This system of large ratios seems destined to prevail and really amounts to throwing away the intermediate cylinder of a triple engine, with all its cost, friction and loss of heat, and by using as high steam pressures in the remaining two cylinders and the same number of expansions we get practically the same results.

* * *

REMARKABLE TIME KEEPING.

There is in the library of the Franklin Institute a clock which has a remarkable record for accuracy. It is an astronomical clock with Riefler's absolutely free pendulum escapement, and Riefler's mercurial compensating pendulum; and though one might imagine such a title would slow down any clock, it proves its accuracy by keeping correct time in spite of it.

An accurate record has been kept since November 1, 1893, and in the ten months intervening its variations have never reached a full second. While this may or may not be a world's record, it is surely time-keeping extraordinary and little improvement is to be hoped for.

* * *

After you have sharpened that milling cutter on a fine emery wheel or grindstone, don't deliberately take the edge off by too long an application of oilstone. Many a milling cutter is dulled as much by the unnecessary use of an oilstone, as by the actual work it does. A little is beneficial—too much is ruinous.

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SEPTEMBER, 1894.

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VOLUME ONE, NUMBER ONE.

During the present business depression in this country, all kinds of manufactured products have fallen in price to such an extent that at no time within thirty years has the purchasing power of a dollar been so great as it is to-day; and although remarkable progress has lately been made in the reproduction of mechanical subjects by photography and engraving, the cost of almost every thing used in connection with such work has declined in like proportion, so that it is possible to produce to-day a mechanical paper (in editions of sufficient size) for five cents a copy, superior in every way to what would have cost twice that amount a few years ago.

Every one says that there are already too many mechanical papers in existence, yet we believe there is room for one more—one which utilizes these recent improvements, and combines the finest quality of work in photography, engraving, printing and paper, with the products of the ablest writers of the day, *and which is sold at the lowest price of any mechanical paper in the world.*

This is what we shall endeavor to make MACHINERY.

* * *

"I wish you success in your undertaking, as a cheap paper of this kind should commend itself to mechanics generally."*—*Coleman Sellers.*

* * *

COMMON SENSE IN ADVERTISING.

Not one man out of ten who advertise in trade papers gets the full value of his money, and the advertisers themselves are principally responsible for this result. Almost every manufacturer considers it necessary to do a certain amount of advertising, but the idea of giving any care and thought to its preparation seldom appears to occur to them. An old clipping set by some job compositor who knows less about the advertiser's business than his office boy, often fills a space costing two or three hundred dollars a year, usually running to the end of the term, and perhaps beyond, without a change. The advertisement of a large firm of engine buiders, which consists only of its name, address and a view of its buildings, has been running without the change of a letter for over five years in some of the trade papers, at a cost in one paper alone of at least $1,500; and no one will deny that fully one-half this outlay represents money thrown away. A well-known Philadelphia firm advertised a ventilator for over a year before it was accidently discovered by an advertising solicitor that they had none in stock. A worse case still is that of a manufacturer who continued his announcement, "Call and see our Exhibit in the Machinery Building," until the year 1894 was well advanced.

Why do so many manufacturers waste money this way in advertising? They don't do it in other branches of their business. They buy their machinery and supplies, and hire their labor with an eye to getting one hundred cents' value for every dollar they pay out; and yet their advertising appropriation is expended according to an entirely different principle.

If we could have our way, every advertisement in MACHINERY would be changed with every issue, and something new would be said every time the advertisement was printed. Trouble? Certainly it's a trouble, but so is every branch of your business if it is conducted properly. Every business that is worth advertising—and this is especially true of the manufacture of machinery—will yield something of interest which, set forth attractively in an advertisement, will cause some persons to read it, and those readers are the very men the advertiser is after.

Of course, with all the care in the world, some papers will not pay advertisers, because they have no circulation or do not reach the right class. Such papers as the *American Machinist, Power*, the *Iron Age* and the *Locomotive Engineer*, which stand at the head of their respective fields, we believe will pay any advertiser who has a good article at the right price to sell the trades they reach, and who will take the trouble to advertise it properly.

Speaking of trade papers, reminds us of something that of course everybody has noticed—they rarely advertise. This seems to us to be a weak spot in their armor, for if they believe in advertising for others, why not for themselves? There are about six hundred thousand intelligent men connected with the manufacture and use of machinery in this country, and no single paper reaches one-twentieth of them. Yet, with the exception of an occasional sterotyped notice, undoubtedly an exchange and worth no more than it costs, which is nothing—we do not know of a single case where a mechanical paper has taken advantage of the un-

* One of many similar voluntary expressions, which it gives us pleasure to acknowledge.

doubtedly good circulation of its contemporaries to widen its own field.

We believe in advertising. We believe it will pay a newspaper as well as a manufacturer, subject to the conditions mentioned; and one of the first appropriations for the expense of MACHINERY was that of a few thousand dollars for this purpose. We may be wrong about the papers, but we are right about the principle; and later we will give our readers the benefit of our experience.

* * *

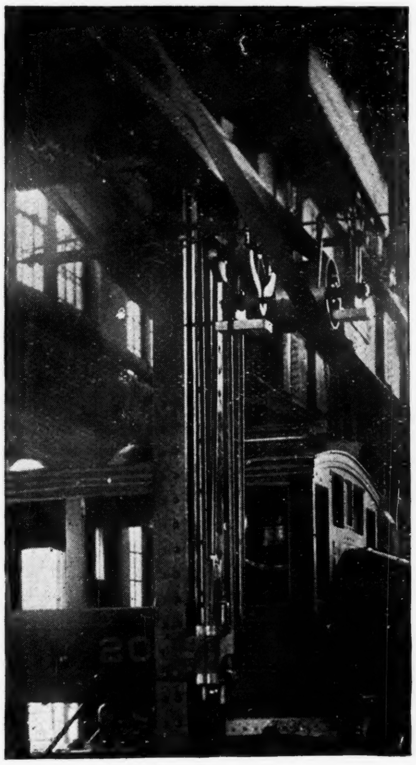
COMPRESSED AIR IN A RAILROAD SHOP.

W. B. RUGGLES.

One of the easiest ways to save time and labor in any machine shop is by the introduction of means for quickly and easily handling heavy material, so that manual labor may be lessened.

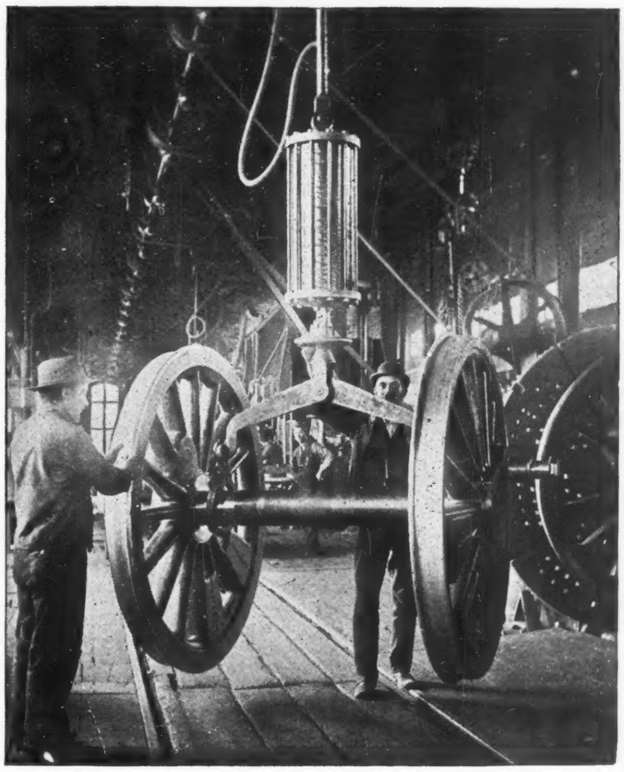
One of the most perfectly equipped shops in the country in this respect is that of the West Shore Railroad at Frankfort, N. Y., under the management of Jas. M. Boon, the Assistant Superintendent of Motive Power and Rolling Stock. Besides the large power crane in the erecting shop, which can lift an entire engine from one track to another, or carry it the whole length of the shop, a complete system of compressed air has recently been introduced for doing other heavy work, which, for simplicity and effectiveness, cannot be excelled.

There are two air compressors of 6 inch diameter by 9½ inch stroke driven by belts from the main shaft on either side of the shop. These work automatically and require no attention except occasional oiling. The air is compressed at each machine into a reservoir 10½ inches by 8 feet 6 inches, placed under the roof. When the pressure in this reservoir drops to 95 lbs., a valve opens letting the pressure into a small cylinder, the piston of which throws over a lever weighted at the top, which shifts the driving-belt from a loose to a tight pulley and starts the pump. When the pressure in the reservoir reaches 120 lbs., the valve is opened, releasing the air from the small cylinder, the piston is carried back by a spring and the belt shifted to the loose pulley, stopping the pump. This is shown in Fig. 1. The air pressure in one case and the spring in the other moves the lever only slightly beyond a vertical position, when the weight at the top drops by gravity and shifts the belt at once. This is to avoid the slow shifting of the belt if direct connection were employed, with the consequent squeaking and wear.



COMPRESSOR AND AUTOMATIC SHIFTER.

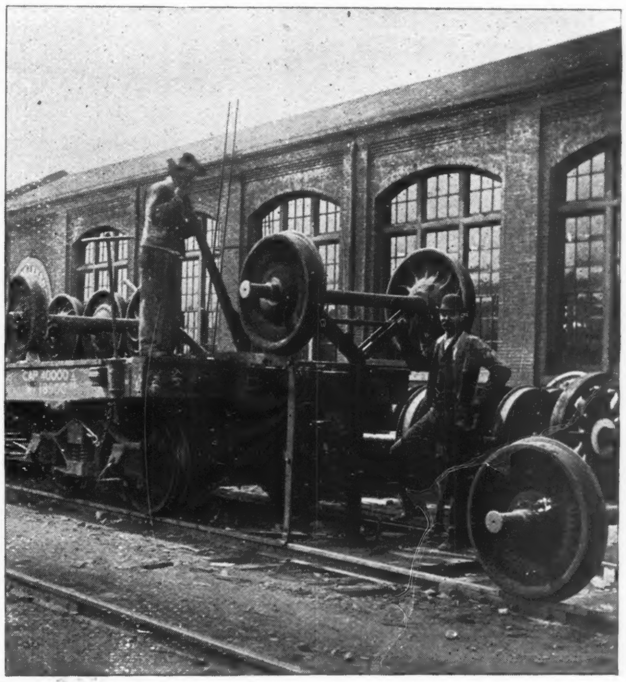
From the reservoirs are carried 1¼-inch pipes extending the whole length of the shop on each side, with drops at convenient points for attachment to working cylinders. These cylinders are made of hydraulic pipe, bored out, with caps on each end. The smaller ones have the caps screwed on; the larger ones have bolts running from one end to the other, holding the heads in position. In each head is cut an annular groove in which leather packing is introduced. The pistons are made in two parts, which screw together with a leather cup between. In operation the air presses the leather against the cylinder so closely that no leakage is apparent, yet when the air is released the piston will drop by its own weight. The piston rod is packed in the same manner by a cup of leather in the cylinder-head. In the top head is bored a small hole ⅛



LIFTING DRIVERS.

inch to $\frac{3}{16}$ inch, which is large enough to admit air above the piston freely, but so small that the head can not be knocked out by a too sudden lifting of the piston.

The hoists are hung from the top heads on overhead tracks and are connected to the pressure pipes by ½-inch hydraulic hose. A three-way valve within easy reach of the operator and a swivel hook complete the apparatus. There are in the shop nine 4-inch hoists for lifting material weighing from 100 to 1,500 lbs. on and off axle lathes, slotters, etc.; five 5-inch for boring mills, large lathes, etc., to lift 2,000 lbs. or less; two 10-inch for cylinder boring machines, to lift 9,000 lbs. or less, and two 12-inch for driving-wheel lathes, capable of lifting 13,500 lbs.



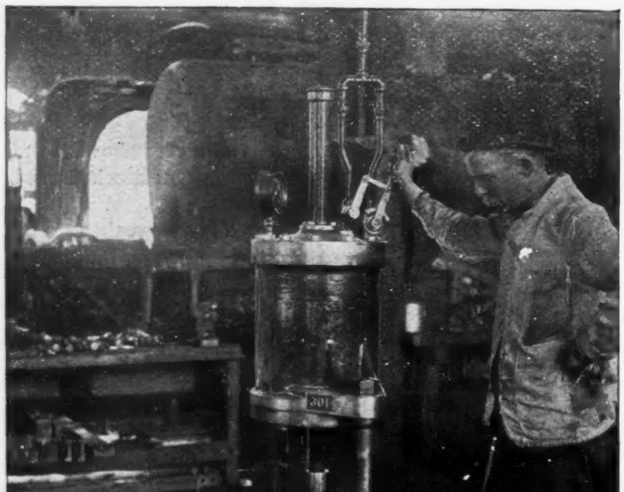
LOADING CAR WHEELS.

We illustrate the operation of one of these in Fig. 2. The wheels are rolled in position on the track underneath the hoist, the piston dropped and claws attached to the axle, the valve

opened and drivers lifted and swung into the lathe with ease. The whole operation taking less than two minutes, where formerly fifteen or twenty were necessary. The hand wheel shown in the illustration is for regulating the height of drivers, for though they may be held and stopped by the valve at any point required, it is found to be quicker to raise them as far as they will go by the piston and then use the hand wheel and screw for close adjustment.

Fig. 3 shows the method used for loading freight-car wheels. A piston 6 inches in diameter is placed in the ground vertically; on the end of the piston-rod, which is made large for rigidity, is a Y-shaped head having a groove on the end of each arm to engage the axle near each wheel. A pair of wheels is rolled into position above the hoist, the operator opens the valve with his foot, and the wheels rise to a height a little above the level of the car. A light movable track is pulled out under the wheels, the piston drops and they roll down onto the car by gravity. In this way a car may be loaded by three men in one-quarter the time it formerly took six men to load by rolling them up on skids. By the old method men were continually being injured, while this is operated with perfect safety. Another hoist similar to this is used for handling single wheels, axles, scrap, etc., from the side of a car; instead of a special head, a platform about four feet square is raised even with the car floor.

Fig. 4 illustrates the use of air in putting in rod bushings. This machine has a 13 inch cylinder of cast iron, above which is a small cylinder into which air is admitted to raise the piston. The rod and bushing are placed into position and about eight tons pressure used to force the bushing in.



PUTTING ON ROD BRASSES.

There are various other uses by which the air is employed, only one of which I will mention. This is a small machine with a 2 inch air cylinder for putting couplings into air-brake hose ends. The hose is held between wooden blocks, and the coupling laid in a special head on the end of the piston rod. This little machine has a record of putting together one hundred in one hour and five minutes, against twenty-five in one day by hand, and actually paid for its entire cost in one day's operation.

The entire cost of power for running the air compressors to supply the whole shop is not more than ten cents per day, and saves from fifteen to twenty dollars a day.

* * *

Considering the numerous fly-wheel accidents in which engineers have been killed or maimed, we are glad to see the idea growing that an auxiliary throttle valve placed out of range of the fly-wheel is a necessity, and should be found in every plant. It is not right to arrange valves so that a man must place himself in range of several tons of metal which may fly at any instant, in order to stop an engine which is racing, and yet we are apt to condemn a man who deserts his post in such an emergency.

THE GREATEST AND THE LEAST.

GEOMETRY POINTS TO THE BEST AND CHEAPEST WAY.

JOHN H. COOPER.

h object of this article is the presentation of such geometrical problems and formulæ as lie in the line of, and which contribute to, the economies of engineering construction. The selections made are from many sources and authorities, all are checked by the conclusions of experience and the whole made simple and practical.

The object of mathematics is to facilitate calculations. In all cases we have, already at hand, certain quantities or dimensions; we next wish to find other certain quantities or dimensions which are as yet unknown.

Without much ado, we will pass over, with a glance only, at those wonderful statements called definitions, bringing forth, as they do, the difficulties lying in the way of correct defining, which must include the thing defined and exclude everything else.

When we are told that, "A point is a mark in magnitude which is indivisable"; that, "A line is a magnitude which has length only, and wants all breadth;" or, as Archimedes puts it, "A right line is the shortest of all those which can be drawn betwixt two points:" furthermore, as Plato hath it: "A right line is that whose extremes hide all the rest (that is, when the eye is placed in a continuation of the line)." We begin to think we have entered on the consideration of simple things, so called, but we find they demand great study.

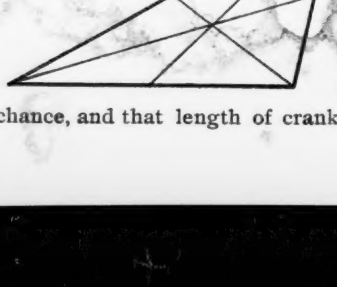
We are then told "the sense is the same in all" 'The instrument whereby right lines are described is called a rule; which, whether it be strait or not, you may know by this tryal." I reproduce the quaint language of 1719, which purports to give the "Elements of Euclid," formulated twenty centuries earlier. The "tryal" referred to directs that, in order to test the straightness of a rule you shall draw a line with it, then reverse the rule on the line; "if it doth now entirely fall in with the line, the rule is strait; if not, the rule is not strait." And here is just where common sense slaps theory in the face, saying, When you want to draw a straight line, why don't you take a "straight edge" and copy that?

Let us go a step further, rounding up by a little recapitulation. "A line is made by the flowing of a point; a surface by the flowing of a line; a solid by the flowing of a surface. A solid therefore hath three dimensions; a surface two; a line one; a point none." Of course we understand that the physical properties of the point, line and surface are excluded—the ideal forms are only considered.

Let us therefore adopt the common sense meanings which are so easily deducible from the ancient word pictures, and which have held their undisputed place in the schools of learning for so long, they may not easily be improved upon. We will further drive a nail by Shakspeare, who said: "Be sure of it; give me the ocular proof;" and clinch it by a quotation from that eminent mathematician and mechanician, Babbage: "To whom a demonstration never seemed complete until he knew how to render it evident to the sense and to the reason."

Mr. Holly, at a meeting of engineers, once said, there were two kinds of engines: one called the boat engine, which has a cylinder of 100-inch bore and a stroke of 1 inch; the other, called a factory engine, with a cylinder 1 inch in diameter and 100-inch stroke. Of course this is a ridiculous way of putting it, but that cylinder diameter goes for power, giving the steam a chance, and that length of crank is for advantage, favoring the

FIG. 1.



mechanism of the engine, are nevertheless true in the main.

To give you Mr. Holly's florid comparison is necessary in order that when you design an engine you will not make a blunder in either extreme. The problem of *the greatest* and *the least* has something to do with the solution of the question of cylinder proportion, which will appear later on.

To determine the shape and cost of tanks or vessels of cylindrical form, which are closed at both ends, is often desirable, and here it becomes important to know the relative proportions of diameter and length, such that the least quantity of sheet-metal and labor may be expended in the production of such tanks.

The greatest volume that may be enclosed by a given surface of the form stated above, is proven mathematically to be that in which *the diameter of the cylinder and its length are the same* —to which the name of *right cylinder* has been given.

Knowing this fact, the finding of dimensions of the tank that shall hold any certain number of gallons, for instance, may be found by this simple formula, which I have devised for these cases:

$$D = 0.5542\ \sqrt[3]{G}$$

In which D= the diameter and length of the tank in feet and G= the number of U. S. gallons that it will contain. That is to say: Multiply the cube root of the number of gallons by the decimal 0.5542. The product will be the *diameter* as well as the *height* of the tank in question, in feet.

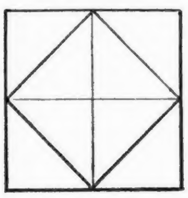
Having made you acquainted with that cylindrical form—*most excellent*—which has the least enveloping surface for a given volume, its application to the cylinders of steam engines becomes an interesting matter, as in these cases exposed surface to contact with air means radiation, or loss of heat and power to the steam, and therefore it becomes necessary to reduce this loss to the least. We see then plainly that this geometrical form solves the problem of how to use steam, in so far as the form of its mass is concerned while being used, with least loss by radiation.

Of course the working parts of any engine, the purposes for which the engine is applied, necessarily modify proportions; also the point of cut-off of the steam influences somewhat the shape of the working body of the steam, but the loss of heat by contact with the confining walls of the cylinder will ever be the *least* when the volume of the steam which actuates the piston approximates most closely to the form of the right cylinder.

In every triangle, if you join each angle by a straight line to the middle of the opposite sides, you will find these three invariably crossing one another in the same point. (Fig. 1.)

Some of the problems of the *minima* are self-evident: for instance, if you wish to inscribe the *least square within a given square*. It is plain on inspection of Fig. 2 that the corners of the inscribed least square must touch the middles of the sides of the given square, simply because the distance across the given square, that is, from one side to the other, is least when it is taken at right angles to the sides of the square; now such a line is not only parallel to the sides of the given square, but is also the diagonal of the inscribed square, and being the shortest distance across, it must represent the least square that can be drawn within the other.

FIG. 2



Referring again to Fig. 2, any one can see that, if you turn the internal square on the common center of both squares either way, its corners will withdraw from the sides of the outer square, which would at once show that a larger square must be made to touch the sides again, if placed in any other position than the one shown.

Another well nigh self-evident statement is, that a given area in triangular form will have the least boundary when its sides are equal. To illustrate this, firstly, upon a given right line A B, erect an equilateral triangle in the following way: From the point A as center, with the radius A B, describe the circle B C I, and from the point B as center, with the same radius, describe the circle A C E J, cutting the former circle in C, from which point draw the lines C A and C B, also join B E and C E. The two triangles A B C and B C E are evidently equilateral. Upon C E extended take any number of points F G H, chosen at pleasure, and join these points with A and B. All these trianges have the same area, because all have the same perpendicular height C D, and a common base A. B.

Inspection of the figure shows clearly that the boundaries increase very rapidly as the vertices F G H recede from C. If we extend the lines C H indefinitely we can never make it coincide with or lose itself in A B, also continued, because they are parallel with each other, and such lines do not approach, much less touch. We shall therefore always have a triangle enclosing the same space, whatever be the length of any two sides, such as A H and B H. The areas of the two triangles A B C and A B E must be exactly equal, because each one is half the area of the four-sided figure A B E C, which is divided by the shorter diagonal B C in one case, and by A E, the longer dagonal, in the other.

Having any given area, we may wish to find the side of the equilateral triangle that contains it. To do this, divide the area by the decimal 0.433 and extract the square root of the quotient,

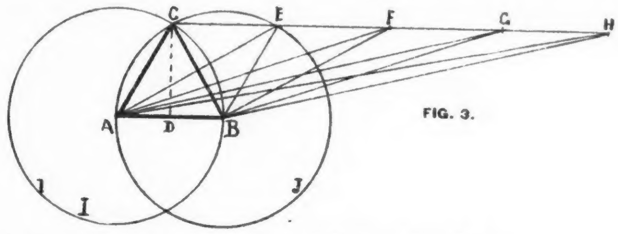


FIG. 3.

or in formula this rule may be neatly expressed thus:

$$S = \sqrt{\frac{A}{0.433}}$$

A curious and convincing illustration of the least boundary enclosing a given area is presented in the following: Consider first the square, that is, the equal-sided, right-angled figure A B C D, Fig. 4, and let us work out the problem by introducing dimensions, thus putting it into practical shape; say we make each side two feet long and then proceed in the usual way of calculating areas and boundaries. (The square root of a given area equals the side of a square figure containing it.) Prolong A B to I, and to K, and on; make B I=A B; bisect A C at E; draw E F parallel to A I, and complete the right-angled figure A I F E.

Next, bisect A E at G and draw G H parallel to A K, complete the figure A K H G by making I K=A I. This process may be continued indefinitely; the figure being narrowed by halving, and lengthened by doubling successively.

Let us now find the areas of these several figures. The area of A B C D is equal to $2\times2=4$ square feet, while its boundary is equal to $4\times2=8$ lineal feet. The area of A I F E is equal to $4\times1=4$ square feet, while its boundary is equal to $4\times2+2=10$ lineal feet. The area of A K H G is equal to $8\times\frac{1}{2}=4$ square feet, while its boundary is equal to $8\times2+1=17$ lineal feet. From these results it plainly appears that the boundary of a given square area increases as the figure enclosing it is narrowed and lengthened, and that this process may be continued indefinitely. Attention is called to the figure itself, which shows the area at a glance, as consisting of four equal square figures having sides of one foot length, for the reason that many readers cannot follow calculations through the multiplication table, by oral statement alone, nor yet by over-learned expressions; but nevertheless can readily comprehend the same thing when it is shown in figure or in solid.

As we approach the infinite of this problem we will have two lines lying parallel and side by side, with a diminishing distance between them; a condition practically impossible of production and well nigh inconceivable, for when the length gets beyond all measure, the breadth collapses to zero on the scale and we fail to understand how the side of a figure infinitely long when multi-

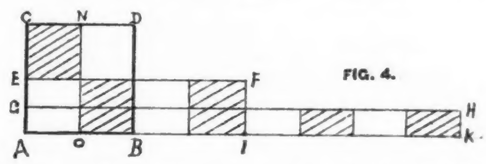


FIG. 4.

plied by the breadth of the same, when that breadth is equal to 0, can give a product of 4, as the sides of the other figures did; but our position is proven, that the longer the figure of given area is made the more boundary it must have to enclose it. We have squeezed the substance all out of this affair, leaving only one straight line, enclosing no area; from a practically perfect figure we have lengthened it out to a meaningless infinite line, so far as enclosing area is concerned.

If, therefore, we wish to bound a given area by four straight lines of least aggregate length, it is very true, as we now see, we must make them equal in length and place them at right angles with each other.

TWO FORMS OF THREADING DIES.

Two forms of threading dies for turret work in brass are shown in this article, and both have been successfully used in this connection, the first one (Fig. 2) being particularly simple, but not so effective for hard work as the next one shown.

Neither of these have been widely used, but have done good work in the shop where they originated, and may be of use to others having hard die work where accurate results are wanted. Beginning with No. 2 we have simply a cast iron case (A) recessed to the proper depth for holding the die to its place and tapped for two set screws, as shown by S and X. The die proper is simply a ring of steel, turned, bored and threaded to the correct size, then drilled or reamed for the taper-point screw S and cut at this point, as shown, about $\frac{1}{8}$ or $\frac{3}{16}$ of an inch wide, or the cut can be made and the places for the pointed screws filed out. Next the relieved portions are cut away by any convenient means and after hardening and tempering the die is done. The screw X is for closing in the portion directly under it, and thus altering the size of the die, but it will be found very convenient where the size is not to be changed to pack the dies with paper or thin sheet metal, for if the screw is not a very snug fit, or unless check nuts are used, the adjustment is apt to vary with the jar of the machine. In practice this die will do good work, for a time at least, but they have an unaccountable way of breaking when not in use as well as when being used, the internal strains of the metal being probably responsible. The other is more expensive and more durable, also more reliable as to maintaining size. It consists of the same case as before (with shank attached in both cases for fitting in turret), but has four separate cutting blocks, C C C C, held in place by the clamping pieces B B B B. The side view shows the cutter C with the back side tapered for the clamp to hold on, the bolts running through the case and having nuts on the back side, having slotted heads for convenience in tightening. Through bolts as shown are much to be preferred to cap screws, or machine screws, for reliability and convenience.

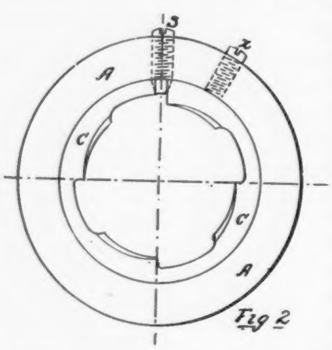


Fig 2

The bolt-hole through case is made with some play to allow of adjustment of bolts and clamping blocks, the operation being very plainly seen from the cut.

A small screw, as shown, can be used for adjustment, and perhaps would be called more mechanical, but paper or thin metal packing has always been preferred by the writer, for several reasons, two of which are the freedom from adjustment by every one who uses it, and the jarring out of screws, as in the other case.

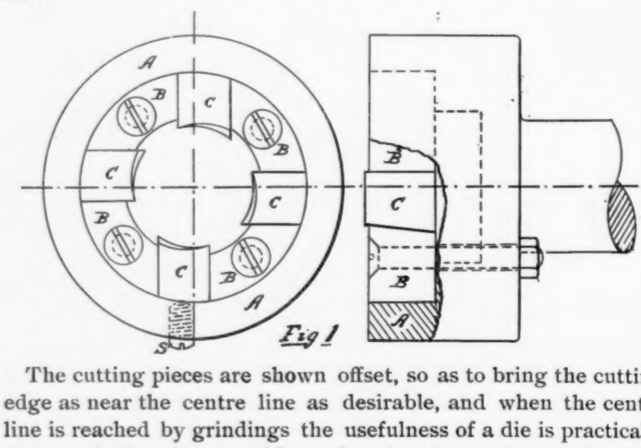


Fig 1

The cutting pieces are shown offset, so as to bring the cutting edge as near the centre line as desirable, and when the center line is reached by grindings the usefulness of a die is practically past, as the bearing or guide surface has been very considerably reduced, and on soft metals is apt to cause stripping of threads.

Practically the die will cut about as well with the cutting pieces put in at the exact four points and not offset as shown, but as many seem to prefer them so as to bring the cutting edges near the center, this arrangement has been shown.

As will be seen, the cutting edge is well supported in each cutter, the overhang is practically as small as possible, and a good solid die is the result, which will cut good threads and do it easily. The cutters can be cheaply made in any way which seems most convenient for the shop you happen to be in; the outer ends can be ground good enough on an emery wheel, if you have no means of turning or milling them. Although four cutters are shown, any number can be used as fancy or the experience of the user dictates.

* * *

MACHINERYS' NOTE BOOK.

COMPOUNDING—POINT OF CUT-OFF.

It may be interesting as bearing on the much disputed subject of cut-off in compounding engines, both locomotive and stationary, to note the experiments tried (not officially) on the Webb compound locomotive, on the Pennsylvania Railroad, a year or two ago.

When it was known that the low pressure cylinder was to be altered so as to have a fixed cut-off, the engineer began a series of experiments on his own account to determine for himself the best point of cut off for the engine's best work.

When the engine was up to speed and doing its best work on fast service, the cut-off in the high pressure cylinders were about as is usual in fast service, but the engine did the best with the low pressure cylinder cutting off at from 75 per cent. to 80 per cent. of the stroke, causing a drop in the initial of the low, but relieving the back pressure in the high pressure cylinders. This gives practically a Woolf engine, and does good service in this instance. Other cut-offs were tried, but this point was found the most economical in coal and best for fast running, and as the engine now has a fixed cut-off at 75 per cent. of the stroke, and is doing as good work as ever (when in service), the experiments seem to have secured about the correct results.

There is a growing tendency towards adopting this principle in compounding stationary engines, with the exception of having the low pressure cut-off adjustable by hand, so that the engineer can alter the cut-off if necessary to suit the load.

CYLINDER CLOTHING.

It seems safe to say that if less attention were paid to steam jackets for cylinders and more to the proper clothing of the cylinder without the jackets, that a better average economy would be obtained. We find many steam engines running at high speed (the worst place for a steam jacket to show any economy), and although they have a steam jacket around them, the walls surrounding the steam jacket are practically bare, having only an apology for a non-conducting covering, and presenting more surface for radiation and condensation than the bare cylinder would have done.

There may be certain places where a steam jacket is beneficial, but it is confined to slow running engines as a rule. Jacket connections must be large and free, drips must be kept open and drawn off, and a constant circulation maintained to have them of value. Unless there is a good circulation the jacket is very apt to act as a condenser and be detrimental in the extreme.

So when we sum up all the necessary expense of steam jackets and contrast their efficiency with a good solid covering of non-conducting material, there is usually little in favor of the steam jacket. There are many good non-conductors that can be used, and it pays to be generous in their use, but a jacket made of well seasoned pine, three to four inches thick and fitted around the cylinder so as to form a solid covering, then being well painted before putting on to exclude the moisture, is hard to beat.

This, after being carefully fitted, should be again painted and neatly covered with sheet iron, and the cylinder should be cool enough at all times to lay your face against without burning it, unless extremely high steam is used. When we compare the cost of this jacket with the steam jacket and its connections, the efficiency of the wooden jacket will average fully as high, and if a steam jacket is used it should be thoroughly jacketed from the atmosphere by some such clothing as here described.

MY WAY.

"Yes, Carter was a good workman, but he didn't do things my way, and when a man works for me he must do as I want him to," was the answer in reply to a question concerning a former workman. Carter was a good workman and had more ingenuity in getting out difficult work than the speaker ever had, and yet because he had a way of his own for doing work he was discharged or things made so unpleasant that he left.

Many a foreman makes a mistake in this, and also deprives himself of chances to learn other and very often better methods of doing work. It is far better to give a man a job to do and

then leave him, or ask him how he would do it, than to dictate to him just the method he must pursue, he very likely knowing some better way.

If the work is not done properly, or if the methods are more laborious and costly, it is proper to insist on a shorter and cheaper method that produces the same result; but do not try to change a man's method when he is doing the work just as easily and quickly, and just as correctly, simply because it isn't "your way."

The most successful foremen and superintendents are those who combine this consideration for men's methods with good mechanical judgment to determine when it is necessary to insist on other methods being used. Rather try to preserve individuality than to destroy it, in all possible places.

OLD BLUE PRINT PAPER.

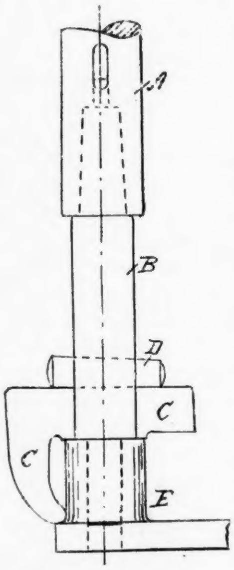
As blue print paper is supposed to, and generally does, deteriorate rapidly with age, it may be of interest to cite a little instance which came to notice a short time ago.

Several prints were made and the supply of paper suddenly ran out, leaving about half the number of prints unmade. Some old paper was found which had been bought about four years before, but which had been laid aside on account of age, and as a possible means of getting out of the difficulty it was tried. The paper itself was quite a dark blue before beginning to print, and to the surprise of all the lines appeared to be getting a deeper blue and the background fading out.

After a five-minute exposure it was placed in the wash-tank, with the idea that it was of no use. It required a long washing, but after it was over it came out as good a print as one cares to see, and it printed nearly as quickly as the fresher paper which had been used. The roll had been kept in a pasteboard roll, and probably fairly free from light, but the length of time between coating and using exceeds any case to the writer's knowledge.

A DRILL PRESS ATTACHMENT

Looking around in the shops of the Manhattan Elevated Railroad not long ago, the writer saw the handy milling or turning attachment illustrated with this, which was doing good work and quite fast also. The work E is a rocker arm, and the hub or boss is being turned or milled by the revolving cutter C. The arm is bolted to the drill-press table, the hole centered with the drill-press spindle A and the bar B, having a tit or projection that fits the hole, and carrying the cutter C held by key D, is all there is to the arrangement. The tit must project beyond the leading edge of the cutter, so as to guide before cutting begins, then it is simply let the machine alone and it will feed and cut to advantage. This makes a cheap job and a good one, when the work is kept lubricated, and should find considerable application in many similar kinds of work. The writer has used a tool very similar in turret work with good results, but as an application to drill-press work it is a handy tool. Similar tools have been used before, but mostly for facing and counter-boring, not for milling, as this one does, although some may have used it.



It might be well to mention that the lubrication employed was from a "sight feed" arrangement of an old oil can, with its bottom suspended to the tool and revolving with it, the ordinary dropping of the oil from the can supplied the lubrication.

LUBRICATING DRAWING TOOL THREADS.

The fine threads of drawing instruments are apt to wear from constant use and also to have more or less friction unless lubricated, but the question is how can this best be done? Oil will not do, as the drawing might be soiled, but a very handy method is to take a fairly soft lead pencil and rub over the threads till they are partly filled with the graphite from the pencil. Then by running the nuts over the threads the superfluous graphite is worked off and the thread nicely lubricated. It is a very simple remedy, but effective and worth remembering, and the threads occasionally treated in this way, with new tools it is almost a necessity, and with old ones it will be a help.

THREE HINTS FOR THE SHOP.

James F. Hobart.

LATHE ADJUSTMENT.

A lathe, to a man unacquainted with that machine, is supposed to be a tool for turning, or dressing down iron or other material to a true cylindrical form. That is: A lathe is to turn a piece of iron to the same diameter all its length, to a true cylinder in fact. But this is just the one thing which a lathe will not do. A *perfect* lathe evidently would turn a perfect cylinder, but the perfect lathe is that particular one which has not yet been built. Probably because there is no perfect man to run it.

To set a lathe to turn true, one machinist will pull the tail-stock forward and make the centers "touch noses," as shown by Fig. 1.

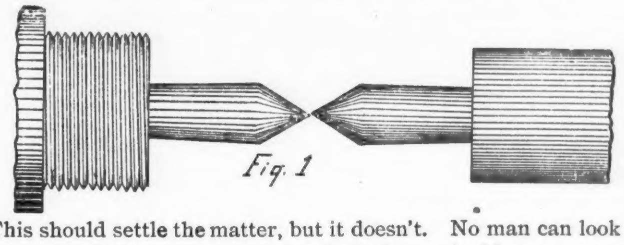


Fig. 1

This should settle the matter, but it doesn't. No man can look at a couple of lathe centers and tell if they coincide to a common axis within one quarter-thousandth of an inch, and that degree of nicety is required frequently in ordinary turning. It doesn't require a micrometer caliper to detect such a difference in diameter. Almost any machinist, with a pair of spring calipers, can detect a "quarter-thousandth" difference in diameter.

Another machinist will look at the "center marks" on the tail-stock pedestal and cap. Most lathes are marked as shown by Fig. 2. When the zero lines coincide, the lathe is supposed to be

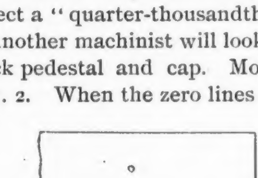


Fig. 2.

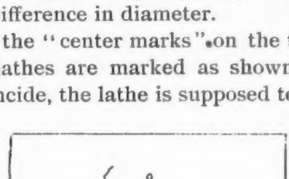


Fig. 3.

accurately centered; but this supposition is not always correct. The marks may not have been made correctly in the first place, and it makes a big difference in the results, where the tail stock stands on the lathe bed. Some lathe makers dispense with the zero marks altogether, and grind the sides of cap and pedestal after the tail-stock has been centered, this permits of adjusting by *feeling*, as the finger can be rubbed over the joint on the side of the tail-stock, and the screws adjusted until no ridge can be felt at the joint *a*, Fig. 2. This arrangement is much better than the zero-mark method, for after a lathe has been used some time, and special marks have been made for the purpose of setting the lathe to special tapers, then the zero marks and vicinity will look like Fig. 3, where marks have been made upon marks, with file, scratch-owl and cold-chisel, until "confusion confounded" is about all that be made of them.

A method of testing the alignment of the lathe at different points along the bed, is to put a long, slim stick in place of the line center, adjust the stick so that the end of it will describe a very small circle, as shown by Fig 4. Then see if the dead center stands exactly in the center of the circle described by the end of pointer stick when the lathe is running. By using different lengths of sticks, the tail-spindle may be tested at any point in the length of the lathe bed.

Fig. 4.

If desired, a pencil can be fastened to the end of the stick, and a bit of wood or cardboard fastened to the dead center, and the small circle recorded thereon to be accurately measured at leisure. But none of these methods quite fill the bill. If a man wants to turn up a piece of iron 20 inches long as truly a cylinder as possible, he can so adjust the lathe that it will make both ends of that piece of the same diameter, but beyond that the lathe cannot go. If the bed is straight and in line, then the cylinder will be straight, but not otherwise.

To adjust a lathe so it will turn both ends of the 20-inch piece

to the same diameter, put the work in the lathe, taking care to have clean deep centers, and all lost motion out of head and tail stocks. Turn up half an inch or so of the dead-center end of the piece of iron, after the lathe has been "set" as accurately as possible by the tail-stock marks. Then, without moving the cross-feed, run the tail-spindle back, remove the work and run the carriage up to the head-stock.

Reverse the work, turning it end-for-end, and tighten up the tail-spindle. Next, run the carriage down so that the tool will come on the turned place, note the position of the tool in relation to the work, and if it does not touch the work, the tail-spindle must be set *back* a distance equal to the space between the tool and the turned place. If, on the other hand, the tool cuts into the turned place, the tail-spindle must be set forward. To locate it, adjust the tool so that it just touches the turned place, then reverse the work back to its original position, and then run the carriage back also; then adjust the tail-spindle screws so that the tool will just touch the turned place, and that the lathe is adjusted to turn both ends of the work to the same size. Extreme nicety of adjustment may be made by filing up the turned place, polishing it, and using for adjustment a tool which will make a very faint mark upon the polished surface.

* * *

PIPE BENDING.

Small iron pipes, up to one inch in diameter, may be bent cold, and even coiled, by winding them around a mandrel in a lathe, provided the diameter of the coil is at least nine or ten times the diameter of the pipe to be bent. Short bends, in iron, brass and lead pipe, are apt to flatten at the bend. This is frequently prevented by filling the pipe with lead, which must be melted out after the bending has been completed.

A set of "bending coils" can be easily made by any machinist, for use when occasion demands. A separate coil is needed for each size of pipe to be operated upon. Steel wire is wound into a coil which will slide easily inside of the pipe to be bent. One end of the coil should be tapered to allow it to enter the pipe easily. The other end ought to be fitted with an eye turned in the end of the wire. Into this eye a cord or chain must be fastened so the coil may be pulled out of the pipe after bending.

The pulling out of the coil does not require as much power, after the bending, as would be supposed, because the pulling of the coil lengthwise causes a decrease in diameter of the coil, which permits it to be drawn easily out of the bent pipe. Wire one-eighth of an inch in diameter should be used for a bending coil for a pipe one inch in diameter; for 1½ inch pipes, one-quarter inch should be used.

* * *

A "SOFT-SOLDER" CHUCK.

Jewellers and watchmakers frequently chuck small articles by attaching them to a lathe face-plate with wax, sealing-wax answers quite well, but some of the craft use a wax, the composition of which is kept more or less secret. Wax will not answer for the heavier work in a machine shop, but solder can be frequently used to advantage. A plain face-plate has a brass plate bolted or screwed to its front, and the plate is tinned, *i. e.*, covered with a coating of solder, one-sixteenth of an inch thick or less.

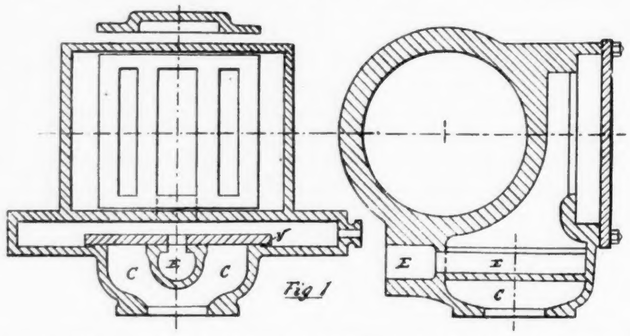
By means of a hot soldering-iron, irregular shaped, small articles of brass, iron or copper may be quickly made fast and chucked in any desired position. After being tinned, the plate may be turned up true, so that the surface gauge may be used for getting the work into any desired position. The object to be chucked may be tinned, before chucking, on the parts likely to be fastened to the face-plate, then, being put in the lathe and held in position against the face by means of a rod or arbor extending to the tail spindle, the soldering may be effected by applying the heat of a gasoline lamp, which may be used to soften the solder on plate and object. While the solder is hot, the object is rapped into position and left a few minutes until the solder sets. Another application of the gasolene lamp will remove the object, and, while hot, the solder may nearly all be rubbed off with a rag, or a bit of waste.

* * *

Plenty of clean windows and provisions for directing the light so as to reduce shadows, will add to the production of any shop.

A PLAN FOR PARTIAL CONDENSATION.

The idea of partial condensation has long been before the steam engineering fraternity, and many attempts have been made to realize a portion of the benefits of condensing, just in proportion to the amount of water which can be economically used for this purpose, and this amount is generally limited (when limited at all) by the amount consumed by the boiler as feed water. There are many engines running which exhausts to the atmosphere with one end and to a condenser with the other, and some cases are noted where only one exhaust from a pair of engines will be used in this way, the remainder being necessary for heating purposes, or water being too expensive.

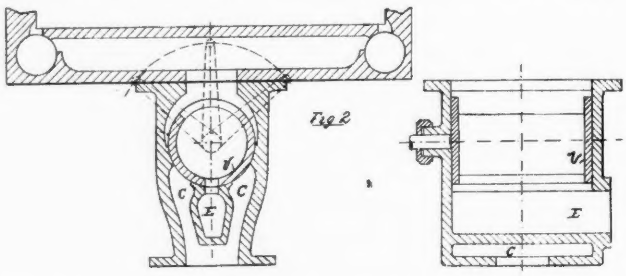


The plan shown with this was designed by Mr. John H. Cooper many years ago, and although it has never been put into practice, owing to lack of opportunity on his part, it appears to possess some valuable features which commend it for a thorough trial at least, and there appears to be no reason why the plan should not give good satisfaction with proper proportioning of parts. The main idea is to have an auxiliary valve as close to the exhaust valve as possible, which shall control the exhaust steam after it leaves the cylinder, and after allowing the first portion of the exhaust to go to the atmosphere or to heating coils, as the case may be, the remainder is to be sent to a condenser whose water supply is the feed water of the boiler, heating the latter and at the same time producing a partial vacuum.

When the release takes place at a terminal pressure of say 30 pound absolute, the opening of the exhaust valve allows the greater portion of the exhaust steam to escape in a body, due to its pressure; but as this first escape reduces the pressure rapidly, the remainder which is turned to the condenser, will be a small portion of the original amount, but enough to fill the condenser and produce a vacuum.

The amount allowed to escape to each place can be determined by the auxiliary valve, as practice shows us how much will be required for the vacuum and how much will be needed for feed water. This auxiliary valve can best be handled by a separate eccentric, and one of the many applications is shown in Fig. 1, which shows it attached to the steam chest of an 8 by 16 slide-valve engine, cutting off at 12 inches, the main valve having a 4-inch travel and the auxiliary valve 6 inches, this being done to secure a quick movement at the opening and closing points.

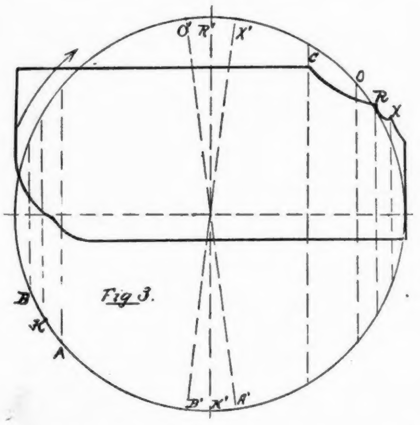
This engine, as scaled by a Bilgram diagram, will give a release and compression point at about 15 inches, there being no inside lap or clearance, and this will be laid out in a diagram later on in Fig. 3. There is little to explain in the cuts, the side view of the steam-chest and cross section of cylinder shows the regular ports and the connection from the exhaust port into the auxiliary chamber, the valve V, with its port over the exhaust to atmosphere E, and the two ports to the condenser C C. In this the auxiliary valve seems unusually long, but it is so of necessity on account of keeping the condenser ports closed against the atmosphere.



Although this has not been drawn for any special engine, it is not far from a fair proportion for a similar engine to the one de-

scribed; the extra width of the condenser ports C C not being required except to keep the exhaust open to the condenser during as much of the stroke as possible. The next figure shows this same plan adopting a Corliss valve and applied to a Corliss engine, although it is quite probable that the best application would be to use the first valve in such a case, as the long exhaust chamber under the Corliss cylinder would accommodate it without difficulty, while the arrangement shown would perhaps make a more compact arrangement for a slide-valve engine. No explanation is required for this view, the working plan being essentially the same as the other valve shown.

In the first case it will be found that if the auxiliary eccentric be set so as to follow the crank about 60° the right movements will be obtained, and a little study of the diagram shown in the next figure (3) will show its work. At C (three-quarters of the stroke) the cut-off takes place, and we expand down to R, the point of release, in which position the auxiliary valve is in its middle position (having commenced to open at O), and the port full open to the atmosphere. This port being but an inch wide, it takes but a small angular movement of this larger throw eccentric to close the port, and after overcoming the small amount of lap necessary to prevent blowing through from atmosphere to condenser, to open to the condenser. During this time the exhaust has been released and the majority of it has escaped to atmosphere or heating coils, but the closing port has confined some of it and probably will cause a slight rise in the release portion of the indicator-card, as shown at X, after which the fall will be rapid, owing to the condenser acting on the exhaust. The letters O' R' X'-B' K' A' show corresponding angles of crank and auxiliary eccentric. This condenser port remains open while the auxiliary travels to its extreme stroke and back again to its middle position, and as this occurs at the point of release of the main valve it will be wide open again at K on the return stroke. But as the condenser port commences to close it is evident that the back-pressure line will commence to rise at A, and will continue to do so, forming the commencement of the compression line when the main valve closes for this purpose, but this must be done in order to have the atmosphere or heating-coil port open for the next exhaust, and the additional compression amounts to very little, or can be regulated to suit. True, this will not produce as pretty cards as a regular condensing engine, but when we consider what may be gained by proper proportions, so as to get the additional area in the lower part of the card, the "picture" part of the card can be neglected. Modifications and improvements can doubtless be made in this device, but the principle is certainly a good one and one which is worthy of further development.



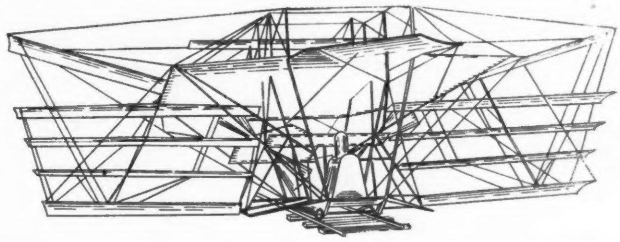
If this can be made to do what is apparently possible, the advantage of using only your feed water for condensing purposes and at the same time getting your feed water heated, is not difficult to obtain.

* * *

THE MAXIM FLYING MACHINE.

The Maxim flying machine, with its successful flight and subsequent failure, due to bending and giving way of the rear braces, is a large braced structure formed of steel tubes and wires, and is exceedingly stiff for its weight, which is about 8,000 pounds, including men and stores. At its lower part it carries a deck on which the crew stand, where also the boiler, steering wheel and reservoirs of water and gasoline are mounted. At a height of some 10 feet above the deck come the engines, each of which drives a screw propeller of 17 feet 10 inches diameter and 16 feet pitch, working in air. Above the propellers is the great areoplane. Smaller areoplanes project out like wings at the sides, the extreme width being 125 feet and the length 104 feet. There are five pairs of wings, as shown in the illustration, but the intermediate three pairs are not always used, and at the time of the accident these were not in place. At that time the area of the aeroplanes was 4,000 square feet. With all the planes in position the total area is 5,400 square feet. Forward and aft of the great plane are two steering planes carried on trunnions at the sides and connected by wire strands with a drum on the deck. By turning this drum the steering planes can be simultaneously tilted to direct the machine upwards or downwards or to keep it on an even keel.

The chief interest centres on the boiler, which is exceedingly light, and, as with the Thornycroft boiler, there are two wing



drums connected by a large number of curved tubes with a steam and water drum, and also downcomers to facilitate the circulation. The casing is also made of straight tubes and a feed heater is placed over the steam drum. The feed heater is constructed of steel tubes $\frac{3}{16}$ inch bore and $\frac{1}{12}$ inch thick; the water is pumped through it at a pressure 30 pounds higher than the pressure in the boiler, and is delivered through an injector-like nozzle into the top of the downcomer pipe. The incoming water delivers its surplus energy to the surrounding liquid, creating a rapid and powerful current in the pipe, and consequently maintaining an active circulation in the small tubes in which the steam is generated. The feed pumps are placed on the deck beneath the engines and are of variable stroke so as to be adapted to the needs of the boiler. As they work at high speed the valves are of large diameter—larger than that of the plungers. Pounding is prevented by a rubber bag on the suction and spring pistons on the discharge. The total amount of water in the boiler only amounts to 200 pounds, so that it is necessary that the amount of feed should be accurately adjusted. The weight of boiler with casing, feed-water heater, dome and uptake is 904 pounds; with burner and water it is 1,200 pounds. The heating surface is about 800 square feet and the flame surface 30 square feet.

The fuel burned in the boiler is gasoline carried in a copper vessel on deck and pumped through a vaporizer into the furnace. The pipe from the pump is led into a vessel having a large gasoline burner beneath it. In this vessel the spirit attains a pressure of 50 pounds on the square inch and a corresponding temperature, in which condition it is of course, highly inflammable. The gas which it gives off is conducted by a pipe passing through the furnace to a jet, like that of a Bunsen burner, at the front of the furnace, and in rushing through it, induces a powerful draught of air, with which it mixes. The combined charge passes through hollow firebars pierced on the upper surface with fine holes and burns in 7,650 separate flames. The arrangement is so powerful that the pressure in the boiler can be raised from 100 pounds to 200 pounds in a minute. The air supply can be regulated at will, while the expenditure of gasoline automatically adapts itself to the needs of the boiler.

There are two screws, each driven by a separate compound engine, having cylinders 5.05 inch and 8 inch in diameter by 12 inch stroke. The steam is distributed by means of piston valves having 3 inch stroke and operated by eccentrics. The exhaust steam is delivered into the air, but Mr. Maxim informs us that he used successfully an air condenser. This seems to be a necessity, because the supply of water would prove a serious load. Even to drive 100 horse-power would require some 2,500 pounds of water per hour, which would be a considerable addition to a lengthy trip, especially if undertaken for warlike purposes in a hostile country.

To supplement or replace the safety valve, by-passes are provided so as to allow live steam to pass directly to the low-pressure cylinders. Instead of blowing off into the air the steam is blown past the high-pressure cylinders, and the fall in pressure is made to do work on the exhaust from the high-pressure cylinders, drawing the steam from the high-pressure cylinders and driving it into the low-pressure cylinders. The boiler will make more steam than the engines can take in the usual way.

The boiler pressure when running is 320 pounds per square inch, giving in the high-pressure cylinder a differential pressure

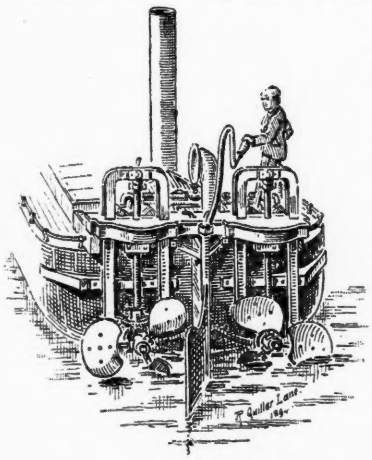
of 195 pounds, and in the low-pressure cylinder 125 pounds. The cut-offs are respectively .75 and .625 of the strokes; in the high-pressure cylinder there is a very large clearance, designed to prevent injury from water in case the machine should pitch. The actual horse-power delivered to the screws is 363 when the engines are running at 375 revolutions per minute. Of this, we are informed by Mr. Maxim, 150 horse-power are expended in slip, 133 horse-power in actual lift on the areoplanes, and 80 horse-power in driving the machine, with its frame and wires, through the air. The thrust of the screws, when the machine is moored, is 2,100 pounds, and when it is running it is 2,000 pounds. We give these figures as they were supplied to us, omitting decimals. The total lift is someting over 10,000 pounds at a speed of 40 miles an hour, and with the areoplanes making an angle of about 7.25 degrees with the horizontal.—*Condensed from Engineering, London.*

* * *

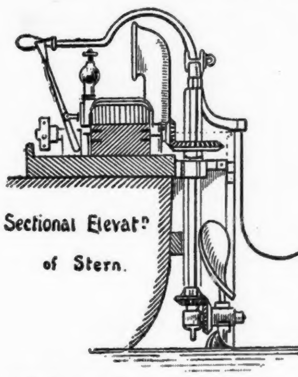
FOREIGN NOTES OF REAL INTEREST.

TWIN-SCREW PROPELLERS WITH ADJUSTABLE IMMERSION.

Under this title we published, on the 10th inst., a paper by Mr. Barcroft giving the results of trials of barges fitted with these screws and driven in some cases by oil engines. A correspondent has made a sketch of one of these, the *Hilda*, of Portadown, and in a letter accompanying the sketch, which we here reproduce, he says: "Each screw is driven by a separate engine—a Vospor two-cylinder engine—placed as shown, and driving the vertical shaft by means of bevel gear. The propeller is driven by a pair of mitre wheels, the screw revolving freely on the short horizontal stud shaft fixed to the footstep, as shown in the section, which is not to scale, however. The rest explains itself, I think. The barge is shown 'light,' and the screws very little immersed. When she was loaded the water would, I think, cover the bosses, but probably no more. The man in charge seemed to have her under complete control, and steered by simply making one screw revolve much faster than the other."—*The Engineer, London.*



Stern view of Hilda of Portadown, showing twin-screws.



Sectional Elevat? of Stern.

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AMERICAN LOCOMOTIVE HISTORY.

The following, from the *English Mechanic*, will prove interesting to our readers who are connected with railroad work:

For many years past it has been known that the chief trouble in obtaining the true locomotive history of the country has always been that the early engines often were built with the same names, and that a number of engines also had their names changed. The subject of the "John Bull" locomotive, sent to America in 1831, has been a puzzle to the American engineers: some persons have claimed it for the Mohawk & Hudson road, and others have been equally certain that it went to the Camden & Amboy line. The difficulty has now been very satisfactorily cleared up, as I have been able to obtain proof that there were two engines of this name in America in 1831.

I have now before me the copy of the working drawings from which one "John Bull" was built at Stephenson's works in 1831 This engine was sent to the Mohawk & Hudson Railroad, now a part of the New York Central. It was in every respect similar to the well known "Samson" class in use in England, and it had a *square* fire-box.

I have also another set of drawings from which, at the same date, the same firm constructed another engine. This was sent to the Camden & Amboy Railroad (now a part of the Pennsylvania system), and when it left Newcastle it was named "Stevens," but on its arrival in America the name was at once changed to "John Bull." This engine was of the usual Stephenson design, but with one most important exception: it had a *round* fire-box, this fire-box having been specially ordered and insisted upon by Mr. Stevens when he gave the order for the engine.

When at the Chicago Exhibition last year I very closely examined the engine shown by the Pennsylvania Company, and since my return home have compared the details with the old working drawings of the engine ordered and named "Stevens" in 1831, and there is most convincing proof that the "John Bull" at Chicago was the real old engine with the round fire-box which was supplied to the Camden & Amboy in 1831.—*Clement C. Stretton, C. E., Saxe-Coburg House, Leicester.*

* * *

A HIGH TEMPERATURE THERMOMETER.

According to *Industries and Iron* the art of making accurate high temperature thermometers has been greatly advanced by the experiments of Mr. W. Niehl, who submitted models of his thermometers to the noted German Technical Society at Charlottenberg in 1893, which were fairly accurate to 550 degrees Centigrade, and who has made still further improvements since that time.

A special glass is required for the tubes of thermometers for this high temperature work, as the ordinary glass would soften under the heat, but by using a boro-silicate glass this difficulty was overcome.

The graduations are on the tube itself, and can be had in single degrees from 180 to 550 degrees Centigrade, or in graduations of 5 degrees from 100 to 550 degrees.

In the models which were submitted by Mr. Niehl the tube was filled with mercury, as usual, and then nitrogen under pressure was admitted above the mercury. This plan is still followed, with a few modifications, carbonic acid gas under a pressure of 300 pounds per square inch being used to complete the filling.

Then the tube is heated, and after the graduations are marked thereon it is emptied in order to have the graduated scale enameled. The tubes are artificially "aged" so as to secure permanent results and avoid false readings due to changes in the tube itself. Experiments showed the untreated tubes to vary from 8 to 10 degrees in a range of 360 degrees Centigrade, and from 16 to 19 degrees when the range was increased to 550 degrees, with an additional error of from 4 to 6 degrees on prolonged heatings for ten hours. After the seasoning process, however, the variations were reduced to less than 1 degree for the entire range of temperature. When we consider that 550 degrees Centigrade corresponds to 1,012 degrees Fahrenheit, we can see the great advantage of having such a simple instrument as a thermometer for determining these high temperatures, when we have been accustomed to more or less complicated and not wholly reliable pyrometers for this purpose. We hope to hear favorably of these in practical use on both sides of the water.

* * *

DEEP MINING.

At the recent meeting of the Iron and Steel Institute at Brussels, some interesting facts were recorded concerning the deep mine shafts of that country. As long ago as 1844 the late Prof. Devillez, of the Mons School of Mines, declared that shafts to a depth of 1,000 meters could be successfully ventilated and worked, and his assertions are now borne out by current practice.

At Viviers the depth is 3,750 feet, at Viernoy 3,300 feet, though both these have been abandoned for lack of coal in paying quantities. At Prodict's colliery the shaft is 3,800 feet, with an incline reaching to 3,950 feet, the greatest depth yet reached in Belgian coal fields. The pumps required for drainage are necessarily powerful though small, to come within the limits of restricted room. Foundations are sometimes omitted and the pumps bolted direct to iron beams built into the masonry. The pump at St. Catherine's shaft of the Boscoup colliery forces the water to a height of 1,180 feet, while at La Louviere the head of over 1,875 feet is handled by one pump on a direct line of piping. —*The Engineer, London.*

* * *

"The Shaw Gas Tester for Detecting the Presence and Percentages of Fire-damp and Choke-damp in Coal Mines," is the

subject of a paper before the Federated Institution of Mining Engineers, who meet at Newcastle-upon-Tyne this week.

Philadelphians and mine workers generally will note with interest the reception Mr. Shaw's invention is accorded on the other side.

* * *

IN AND ABOUT WILMINGTON.

At the shops of the P. W. & B. R. R. we had a wheel lathe pointed out, which, in view of the time of its construction, had some remarkable features.

Its design is so modern that one never suspects it was built as long ago as 1848 or 1850, but such is the case, and it reflects great credit on its designers, R. H. Barr & Co., of Wilmington, long since out of the business. Even the design of the tool-post pedestals (for it carries two tools) are surprisingly like the one beside it, of a well known modern make, and while this old machine only drives from one end, it will turn a pair of tires just as quickly as the newer machines, and it is preferred by the men, who receive the same per piece or per pair, as they do on the new machines. It also does larger work than either of the new machines, although being about the same in size of bearings, etc. Here, too, we find what was probably the first pneumatic hoist applied to railroad shop use, which was put into service in 1885, under Mr. Gordon's regime, and does its work of handling car wheels and trucks in an excellent manner. For later developments in this line see the plant described in another column.

The J. Morton Poole Co. were just preparing to ship a large triple-expansion engine of the vertical type to the Edison Company, of San Francisco, while its mate was also nearing completion. Its cylinders were as follows: High pressure, 16¼ inches; intermediate, 23⅞ inches; low pressure, 38½ inches; the stroke of all three being thirty inches. The high pressure cylinder has one piston valve, while each of the other cylinders have two of the same type. This company are also building two engines of the type designated by Mr. George S. Strong for electric power, one being of 150 and the other of 300 horse power. Engineers will remember Mr. Strong's claim of low first cost and simplicity of construction, together with low repair expenses, and those interested in railroad work will remember him from his locomotives and their performances.

Harlan & Hollingsworth are taking advantage of the cessation of their usual rush of business to erect new shops. The smaller one is a frame building for a blacksmith shop for their ship department, 37 by 150 feet and having a slate roof, to be thoroughly provided with cranes and other appliances for handling work. A much more extensive building will be their new mould loft and tool shop, the latter being on the first story, 18 feet high, and the mould loft on the second floor, with a height of 12 feet. This building will be of steel, furnished by the Edgmoor Bridge Works, and will be 63 feet wide by 254 feet 6 inches long, also having a slate roof. The tool shop will contain punches, shears, rolls and similar tools, some of which are being made by the Hilles & Jones Co., also of Wilmington. In this as well as the blacksmith shop, every appliance for cheap and convenient handling of material will be employed. This firm has been burning crude oil under their boilers in place of coal for about two years, and while no exact data could be obtained from the man in charge of the boilers, the cost was said to be approximately the same, but the freedom from dust and ashes, saving of labor in handling of coal, etc., made the use of oil preferable. Two systems are installed, one to use air as a sprayer, and the other using steam, the latter being preferred in this case.

* * *

Friction in a machine shop is an unknown quantity except where accurate tests have been made, and it seems safe to say that an appreciable amount of saving can be made by a careful study of all the transmission devices employed in the shop. Main shafts, muleys, countershafts and machine bearings all help in making the total friction load.

* * *

Don't wait till the grindstone only hits the tool three times in a revolution before you true it up again. Keep a piece of half inch gas-pipe handy and show the boy how to turn it off as soon as it begins to show a low spot. Turning off a sixteenth may make it true, but if you wait until to-morrow it may take a quarter of an inch. It is economy to turn "little and often."

One of the funniest mixture of ideas I ever heard was when a foreman, who ought to know better, gave a young draughtsman points on the shrink rule. They were talking about pattern makers' allowances, and the young man (who had never worked in the pattern shops) asked how it differed from the ordinary rule.

"Well, John," said the foreman, "the pressure of iron always swells the mould and makes it larger than the pattern, so they make the shrink rule *shorter* than the standard length to allow for this *expansion*." Large castings are frequently larger than intended, from the sand giving to the weight of metal, but the advice regarding the shrink rule will hardly become a foundry maxim.

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Classified Index to Advertisers.